DOCUMENT RESUME

ED 401 820 HE 029 669

AUTHOR	McArthur, David; Lewis, Matthew
TITLE	Untangling the Web: Applications of the Internet and Other Information Technologies to Higher Education.
INSTITUTION	Rand Corp., Santa Monica, CA. Inst. for Education and Training.
REPORT NO	RAND-DRU-1401-IET
PUB DATE	Aug 96
NOTE	98p.; Prepared by the California Education Roundtable.
AVAILABLE FROM	RAND, 1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2318; World Wide Web: http://www.rand.org/publications/DRU/DRU1401/
PUB TYPE	Reports - Evaluative/Feasibility (142) -- Reports - Research/Technical (143)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Computers; *Educational Innovation; *Educational Technology; Higher Education; Information Policy; Information Science; *Information Technology; *Internet; School Restructuring; Teaching Methods; *Technological Advancement; *World Wide Web

ABSTRACT

This paper is a broad review of ongoing and planned applications of the Internet and World Wide Web in higher education, and an analysis of key technical, educational, and broader social issues that these applications highlight. The report attempts to address the following issues about the Internet and the Web: (1) their potential for changing higher education; (2) their potential in helping universities reduce costs, as well as the possibility that distance learning, digital libraries, and virtual universities may make education available to students cheaply, and at any place or time; (3) the possibility that the Internet and World Wide Web may threaten higher education more than help it; (4) the possibility that for-profit providers who now deliver corporate training will compete with traditional colleges and universities; (5) possible responses of higher education institutions to such competition; (6) acquisition of needed hardware and software by institutions of higher education at affordable prices; and (7) the need for faculty to quickly adapt to styles of teaching and learning that, for example, emphasize interactive mentoring instead of traditional lectures. The report stresses that information technologies will transform the processes and products of learning and teaching and discusses some of the costs and benefits of such transformations, and the policy issues surrounding the prospect of fundamental structural change. (MAH)

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Untangling the Web: Applications of the Internet and Other Information Technologies to Higher Education

David McArthur, Matthew Lewis

DRU-1401-IET

August 1996

Prepared for the California Education Roundtable

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PREFACE

In just a couple of years the Internet and World Wide Web have transformed communication, scholarship, and business. But what potential do they hold for changing higher education – the place where this technology originated over twenty years ago? Will it help universities reduce costs, in the face of often dramatic budget reductions? Will distance learning, digital libraries, and new "virtual universities" make education available to students cheaply, and at any place or time? Or might the Web threaten higher education more than save it? Will nimble for-profit providers, who now increasingly use the Internet to deliver corporate training, soon turn to the education market and compete with traditional colleges and universities? If so, how might higher education institutions respond to this problem? How will they acquire the hardware and software needed to offer high-quality educational services at prices that they can afford? And how can faculty quickly adapt to styles of teaching and learning that, for example, emphasize, interactive mentoring instead of traditional lectures?

This paper is the product of a small RAND study that attempted to frame and develop some answers to these questions. It is intended both as a broad review of on-going and planned applications of the Internet and Web in higher education, and as an analysis of key technical, educational, and broader social issues that these applications highlight. We hope that this report will stimulate discussions regarding the costs and benefits of Web technologies in learning, the different models for providing education that these technologies offer, and the changing relationships between traditional higher educational institutions and a new generation of providers. Decision-makers who are concerned with these technical and policy issues are a main audience for this paper. It should also be of interest to academic, research, and business professionals who are concerned with applications of information technology in education and their social implications.

The study was sponsored by the California Education Roundtable, and was carried out under the auspices of RAND's Institute on Education and Training (IET), directed by Dr. Roger Benjamin.

For further information on this study, contact Roger Benjamin (Roger_Benjamin@rand.org), Matthew Lewis (Matthew_Lewis@rand.org) or David McArthur (David_McArthur@rand.org). This paper is also accessible on the World Wide Web at http://www.rand.org/publications/DRU/DRU1401/. In the on-line version the Web sites mentioned here are represented by active links to the sites themselves.

SUMMARY

Until very recently, discussions of the crisis in education centered exclusively on public schools in the United States; higher education has been viewed as virtually trouble-free – the best in the world. Today, however, several problems loom on the horizon. In many states budgets for higher education are falling; some are poised for truly terrifying reductions. At the same time industries and consumers are demanding more of colleges, even as resources are shrinking. Student populations are increasing in size and becoming more diverse (in age as well as ethnic composition). Further, a broad shift from manual workers to "knowledge workers" means that students will require ever more education: high school diplomas no longer guarantee good job prospects. And many predict that job skills will need updating every few years; if so, "lifelong learners" will continue to demand education and retraining throughout their careers. All this is straining institutions of higher education to the breaking point.

In this paper we look broadly at the prospects of meeting some of these challenges using a new generation of information technologies. Our review and analysis examines, in particular, how the emerging global information infrastructure – the first pieces of which we now see in the Internet and World Wide Web – can play multiple roles in higher education. While our analysis suggests many reasons for optimism, we do not regard information technologies as an unqualified answer to the problems of higher education. We believe many of the most effective uses of technologies will not improve productivity in higher education in any simple sense; rather, they will transform the processes and products of learning and teaching. As a result, they may threaten the current structure of the university more than just streamline it. Some of the costs and benefits of such transformations, and the policy issues that surround the prospect of fundamental structural change, are discussed at the end of the paper.

Improving Learning and Teaching

As resources for higher education dwindle, many now look to information technologies to improve productivity by reducing the time, money, and teaching resources needed to help students learn. In the past, distance learning applications have demonstrated some of the most impressive cost savings. Today, several lines of evidence suggest that the Web may be the most cost-effective way to deliver distance learning courses in the future. Classes from the World Lecture Hall Web site, for example, already include a wealth of multimedia material – including lecture overheads and

annotations, digitized lecture audio, electronic archives of past final exams, pointers to online libraries, and even interactive simulations that can be run at a distance. High bandwidth interactivity will be available soon, to support multi-person, multimedia dialogues in real-time. The new generation of Internet-based distance learning courses, therefore, should provide substantially richer learning experiences for students than the current one.

At the broadest level, we believe an Internet style of learning or instruction delivery will be so common that it makes little sense to view distance learning as a special case. Since Internet and Web tools will continue to drop in cost and increase in functionality for the foreseeable future, information technology should continue to displace more and more faculty labor. Further, what labor cannot be displaced will at least not have to be nearby – the Internet can connect students with faculty and peers as easily as it connects learners with multimedia documents. Eventually, then, most learning will be distance-independent, and the special cases will be those that are "geographically bound".

While many applications of information technology in education try to reduce costs, others focus on the "output" side of the productivity equation, helping students learn more, or better, or to learn new skills – ones rarely included in higher education curricula. For example, intelligent tutoring systems, which try to capture in software much of the reasoning and knowledge of expert tutors, have lead to some dramatic improvements in student learning. More innovative applications of information technology follow a very different principle: instead of mimicking human tutors, they provide rich simulated environments that enable students or trainees to practice skills very intensively. Today many of these applications run only on high-powered machines. Soon, however, emerging standards will permit them to be accessed by students who might have only low-end machines – and virtually any kind of low-end machine, not just ones that the original application developer envisioned.

The Internet and Web, therefore, promise a wide variety of tools for teaching and learning, not just one or two. Selecting among the different choices demands attention to the (often implicit) educational goals the technologies address. Some might help higher education institutions reduce costs; but others look better suited to increasing access to educational resources, or increasing the quantity, quality, or speed of student learning. In addition, while many applications clearly intend to help speed-up learning, or improve learning of well-defined subject areas, it is much less obvious how others improve educational productivity in any simple sense. Instead, they are trying to transform the *processes* and *products* of learning. For example, they might exploit new visualization technologies to enable junior students learn about complex systems that previously only grad students found comprehensible; or they could foster deeper understanding through inquiry-based learning rather than traditional lectures, or through collaborative learning methods that simply never existed prior to high bandwidth networks. In short, here information technology is a driver of educational reform, not of productivity enhancement – unless productivity is redefined to include a wide range of qualitative changes, not just quantitative improvements.

Improving the Creation of Instruction and Learning Materials

In addition to providing tools for teachers and learners, information technology can also help create new instruction and learning material, improve its organization and access, and speed its development. The traditional pipeline for producing educational materials (and intellectual artifacts in general) consists of many parts, but four are central: authors create documents; publishers mainly manufacture and market copies of these products; libraries primarily acquire, store, and distribute copies to the nearby community; and readers consume them. These groups have played relatively stable roles in the publication process for decades, even centuries. However, information technology is changing these roles; and, equally importantly, it is transforming the copyright and intellectual property right laws that underpin relationships among the players.

The simplest view of this change argues that new information technologies will reduce, perhaps even eliminate, the need for publishers and libraries. Traditional academic publishers have approached the Internet very reluctantly. The Web calls up their worst nightmare: they sell one copy of a digital book, then all others are produced for free with a few mouse clicks. Compared to larger traditional publishing firms, small "grass-roots" publishers on the Web, look to be nimbler providers of new digital courseware that will meet changing industry needs. Just as information technology already helps manufacturing and services industries dramatically shorten production cycles, individual publishers might help higher education to meet the rising need for "just in time" or "on demand" learning.

Web sites like the World Lecture Hall already demonstrate some of this flexibility. The Hall provides a location and supporting tools that would encourage faculty not only to create new on-line course materials, but to share them with others. Because the Hall is implemented as a Web homepage, all materials from a course can be down-loaded, trivially, from the Hall site to the browser's home machine. Using simple digital cut-and-paste tools, this copy can be edited into a new course, possibly one for a slightly different topic and audience. The new version can be returned to the World Lecture Hall, adding again to the materials available to share with the academic community. Eventually, this kind of "chaotic cooperation" might lead to a vast collection of digital courses of progressively better and better quality, as a new set of course creators "stand on the shoulders" of the current crop. This kind of highly informal cross-institutional collaboration has been common in academic research. But, in the past most higher education institutions have been much more reluctant to share their course offerings, informally or otherwise. Individual academic publishing, therefore, may stress or even transform existing institutional structures, rather than simply enabling them to operate more productively without fundamental change.

Creating Educational Communities

The World Lecture Hall is one of many new academic and learning communities that are beginning to flourish across the Web. Most of these communities are organizing along functional lines – developing courseware, conducting research, sharing curricula, for instance. Common interests and expertise are much more important in defining these communities than distance, a factor that cheap high-bandwidth connectivity largely erases. For similar reasons, most cyberspace communities tend to ignore institutional boundaries where they conflict with emerging functional interests. These forces are beginning to give rise to new communities of practice that, at the very least, criss-cross previous structures, and, more extremely, can erode old higher education structures while building new ones.

Virtual universities may be the most extensive (and certainly most publicized) examples of electronic communities. A few already exist, at least in prototype form. Some of the most complete virtual universities on the Internet, however, are not extensions of existing institutions, but ones that have been created in cyberspace almost from scratch. Though they by no means rival their traditional counterparts in size of faculty or range of courses, on-line universities like Athena are beginning to put together digital versions of all of the familiar pieces of a campus. Like a typical university, Athena grants liberal arts degrees (though it is still waiting to receive accreditation from a regional accreditation body), has a transfer credit policy, and offers a detailed, and surprisingly traditional, core curriculum. Athena differs substantially from most higher education institutions only in its admission policy (because finite resources like classroom space are not an issue, enrollment is open and unlimited), and its teaching methods. Otherwise, Athena is quite consciously an attempt to capture the best of traditional university structure in a virtual version.

But this is not the only approach to developing a virtual university, nor necessarily the most fruitful one. A few groups are viewing cyberspace an opportunity to rethink the structure of educational institutions from the foundations up, rather than as a new tool for an existing organization. The Globewide Network Academy (GNA) is one such experiment. In a broad sense, GNA is something like a mix of Athena and the World Lecture Hall. Like Athena (and unlike the World Lecture Hall), GNA offers more than just a collection of on-line courses; it also includes virtual discussion lounges, where teachers, students, administrative and support staff and technical experts can engage in on-going electronic discussions about the academy. The student lounge also contains a collection of links that comprise an ad-hoc digital library, and another set of links to career resources. Like the World Lecture Hall (and unlike Athena), however, GNA is not developing its own courses. Rather, it encourages institutions and individuals to list with GNA existing courses for on-line distance learning, and then provides a collection of *value-added* and *brokering* services to help students find the courseware they want and to put them in contact with the providing institutions. At the same time, GNA offers support services for teachers and contributing institutions that, they hope, will improve the quantity and quality of the products GNA manages.

In general, higher educational institutions have been reluctant to experiment with more novel designs for using information technology, such as those embodied by GNA: not only are newer ideas tougher to devise and more expensive to implement, but digitizing old institutions may still seem like a perfectly serviceable, and much more certain, strategy. However, if current higher education institutions are not interested in conducting high-risk experiments, new external providers of educational services are more than willing to try. If they succeed, they may make holding to the status quo less and less tenable.

Competing with New Providers

External providers or education have offered a variety of courses and services for decades – from full degrees to short courses and training seminars. The biggest (over $50B per year) and certainly fastest growing (more than 15% a year) part of this sector belongs to companies that provide corporate training. Courses here cover everything from mastering the nuances of Windows95 to acquiring much more generic skills in object-oriented programming, analysis, and design. Not surprisingly, the courses are not only about high-tech, but use high-tech: they generally come from external providers who specialize in training products that make the heaviest, and often most innovative, uses of information technology.

How does information technology affect higher education's problems in competing with these new external providers? If anything, it is exacerbating them, not easing them. Several strands of evidence argue that proprietary providers already think that information technology has helped reduce delivery costs to the point where even "down market" (read: higher education) services can be delivered profitably. Unfortunately, higher education institutions, as a whole, have not formulated any plans to deal with the increasing encroachment of external providers on their turf. They need to.

Several options are worth consideration; only a few have been tried seriously. One approach is to shore up defenses against invaders into traditional higher education markets. This can be done, for example, by erecting protectionist barriers which discourage new providers from entering the battle. Perhaps a more positive tactic is to improve productivity in the face of new competition. Many of the enterprises we review – distance learning campuses and virtual universities, for example – can be regarded as ways higher education already is trying to become more productive, sometimes by borrowing models of delivery from the training sector, and often by creating innovative models of its own. A different strategy is to take the offensive, rather than honing defenses. In part inspired by movements of external providers into higher education's turf, a few institutions are beginning to respond to the challenges posed by external providers by moving, however cautiously, into contract training. But the going here will be hard. Not only are external providers brimming with experience, cash, and technology, but existing institutional policies often handicap higher education from the outset. Business clients, for example, frequently expect to be able to mix their instructors with college personnel; however, this often conflicts with union contracts that forbid hiring external staff.

Policy Issues and Planning

Our discussion raises a number of research questions and policy issues concerning whether applications of the Internet and Web in higher education are technically and economically feasible – and, if so, how institutions should design their technology plans to make best use of these technologies. We focus here on just a few key questions and policy recommendations.

How will higher education acquire sufficient Internet infrastructure?

On the surface, possibly the biggest barrier to moving higher education onto the Internet and Web in a big way is technical feasibility. Many higher education institutions are now developing and implementing technology plans for distance learning around technologies with much less functionality than the Web will shortly offer – for example, videotape sent through the mail, one-way TV (over cable channels) augmented with two-way audio (through telephones), or two-way video-conferencing using special-purpose hardware. To some of them, a proposal to use the Internet and Web for fully interactive, high-bandwidth, and multimedia courseware must look very premature.

We argue that it is not. Further, we suggest that commercialization, sometimes viewed as a threat to the small pristine academic community that used to be cyberspace, is, instead, a key to making the necessary broadband infrastructure widely and cheaply available. To realize this opportunity, however, higher education should take several steps – and quickly, since windows of opportunity are beginning to close.

- *Coordinate technology plans and purchases.* The simplest thing higher education institutions – actually *all* educational institutions – should do is to change their model for technology acquisition. Today, schools at all levels buy hardware, infrastructure, software and support services for computers and networking in a piece-meal fashion. When buying standalone computers this is merely unfortunate: bulk purchases are much cheaper. But when acquiring networking infrastructure it is a fatal error: networks that cannot interoperate are nearly useless.

- *Exploit the Telecommunications Act of 1996.* The Act touches on a wide range of issues dear to the hearts of communications giants, electronic publishers, the entertainment media, and educators. With the Act's passage, many think the best window of opportunity to influence policy in ways that will benefit education is now gone. Not so. In fact, the Act ignores several critical issues, delegates some decisions, and defers yet others to later dates. Internet capabilities available to higher education, and their costs, could look very different, depending on the outcome of political fights still to come in Washington and the states. To influence these debates, higher education institutions should unite behind a broad common vision of their goals and the technology required to get the job done.

- *Pursue options for inexpensive end-user machines.* Even if higher education institutions can secure the infrastructure needed to supply generous amounts of richly interactive courseware across the Internet, students will still need to interact comfortably and cheaply with these products. Many already can, of course. But, if education on the Internet is to be as readily available as education in the classroom, then students of all ages will need virtually universal access to on-line courseware. Today, this is not the case. Several options are emerging that might meet this need: Internet appliances may drop in price to a point where most students can afford them; universities could supply machines for students (some already do); libraries and other community venues could provide Internet access; manufacturers might consider pay-terminals (analogous to pay telephones); and governments could use vouchers as well as other forms of cross-subsidy. The costs and policy implications of these and other potential solutions must be analyzed carefully.

How will higher education acquire quality courseware and educate staff?

If universities and students soon enjoy lavish Internet capacity, they still will need quality Web products for learning that make good use of this potential; in turn, faculty will need to acquire the tools and skills with which to create Web-based distance learning courseware. Many have argued that the cost of developing new products and providing faculty education will be prohibitively high, especially considering shrinking budgets in higher education. To the contrary, we suggest that much of the necessary training can be accomplished within existing budgets – provided colleges and universities are willing to adopt some creative solutions.

- *Use existing tools and training.* Many of the tools needed to develop Web-based courseware, and most of the training needed to become proficient with these tools, are already available. We recommend that universities adopt these rather than developing their own. Certainly higher education will need to revamp many programs to help faculty acquire new teaching skills – ones better suited to technology-intensive classrooms, that, in the future, will be less dominated by lecture and more driven by collaborative projects or on-line mentoring. But to delegate all training on Web publishing to education schools might risk duplicating services unnecessarily, since, on-line communities are already poised to do much of the job. Here is yet another case of new electronic communities that criss-cross the boundaries of traditional higher education institutions. Higher education must find strategies for coordinating with them – in this case if only because much of the literature and training they offer is good, and free.

- *Shift staff time from teaching to creating courseware.* Courses and communities might help faculty acquire skills in Web-based courseware development, but one big question remains: where will the time and money come from to pay for all this? We suggest that it can be done at roughly current levels of funding, providing faculty can reallocate the time they devote to different teaching activities. Since information technology is slowly beginning to displace faculty in some of their traditional teaching roles, staff could spend more time creating courseware. If the transition from lecture-intensive curricula to Web-based courseware is managed reasonably, the added course development time may come at little or no increased cost to higher education institutions.

- *Nourish grass-roots publication.* Higher education institutions can also encourage the development of quality Web courseware through tactics that help foster and manage the "grass-roots" or individual publishing which we see taking shape in on-line communities like the World Lecture Hall. Universities and colleges could follow GNA's lead, for example, and provide a common infrastructure for on-line courses. Perhaps they would do even better to copy proprietary institutions (such as Microsoft's On Line Institute) that supply value-added services which establish goals and areas for new courseware, offer technical assistance to courseware developers, and furnish quality-control standards. In addition, setting standards for courseware format (to ensure interoperability) will probably be as important as content standards. Overall, these intent of tactics must be to foster a culture of sharing in online communities of higher education.

How will higher education choose among many models for using the Internet and Web?

Assuming higher education has the financial, physical, and human resources necessary to use the Web and Internet, what structures or models should it adopt to deliver educational services? Perhaps both the biggest blessing and challenge of the Internet is that makes possible so many alternative models for learning, teaching, and education delivery. We cannot recommend a single model. Rather, we suggest that higher education institutions should examine many possible models, choosing and tailoring ones that are most consistent with their missions and financial constraints, and that also take account of looming sea changes in the educational market: the growth of new private providers, the increasing diversity of student populations, and the rapid turnover of skills in emerging knowledge-based industries.

We further recommend that higher education institutions make a deliberate attempt to consider models which bring into question as many features of traditional institutions as possible – for instance, the length of courses, the size of classes, the bundling of now-separable services like courseware creation, delivery, and student credentialling. We recommend this thought experiment not necessarily because traditional institutional structures are terribly flawed, but rather because points in the "space" of alternatives nearby familiar models are likely to be explored, while more distant ones may go unnoticed. More than anything else, we hope to trigger discussion of these unusual, and sometimes useful, alternatives.

INTRODUCTION AND OVERVIEW

Information technologies have played a vital role in higher education for decades. Television started sending instruction to campuses and homes during the 1950's (remember Sunrise Semester?); before that, radio as well as film, were used in a wide range of courses. But only recently has interest in educational applications of information technology reached nearly epic proportions. In the past, discussion of educational technology was mainly limited to academic and teaching journals; now almost every major newspaper has devoted at least a series of articles or a Sunday supplement to "Learning in Cyberspace".

As veterans in the battle to move computers into classrooms, we are naturally excited by this surge of interest. But we are also nervous. This is not the first time technology has been touted as a savior for education, and all previous "revolutions" have failed. Of course, past failures have not been complete; after all, instructional TV and computer-based integrated learning systems, for example, still persist in schools and campuses, although mainly on the margin. And, newer technologies – from CD-ROM-based multimedia products to Internet "chat" rooms – are potentially much more powerful than previous technologies, so they should avoid many prior technical limitations. But we believe the impending information technology revolution also may fall far below expectations. With the hope that we can help the revolution move forward, we offer here a critical yet constructive review of the potential opportunities that new information technologies afford for higher education.

The Plan

Our discussion begins where almost all of the slightly starry-eyed visions of education in cyberspace do: with examples that illustrate many interesting cutting-edge applications. But, unlike many discussions, ours focuses on information technology as a tool to help solve looming problems in higher education. The central problems we consider include: the need to reduce costs and to increase productivity in the face of dwindling resources; the challenges of an expanding and increasingly diverse student population (including minorities and geographically isolated rural or inner city population, but also "lifetime learners" who must retool their skills); the necessity of adapting to changes in industry and social demands (a broad shift away from manual workers and towards "knowledge workers"); and competition with a growing number of new external providers (often focusing on corporate training but almost always exploiting IT). We will look at applications that at least try to address these problems.

Following this, we will conduct a brief critical reality check to summarize the evidence about these applications. We will claim that some are less than they seem; that others may be more promising, although perhaps less obvious or colorful; and that many of even the most promising uses of information technology in higher education come with hidden costs – ones that must be paid if they are to deliver what they suggest. This, then, will lead to a more full discussion of the barriers to realizing the potentials of new technologies in higher education, and, finally, to some broad policy issues that surround the resolution of these problems.

A Qualified Vision

At the risk of giving away our punch-line (and also of sounding too starry-eyed ourselves), we admit at the outset that we do believe that information technologies can help higher education reach many of its goals. We will even stick our necks out a little further: as many of the examples we discuss will show, our vision is organized around the *pervasive use of interactive and high bandwidth communication networks.* In particular, the model we champion is the Internet, the World Wide Web (WWW), and its generic tools (e.g., "browsers" like Netscape), used to create and run applications (now often called "homepages"). But its not quite today's Web we think could revolutionize education and learning. Obviously, the Internet and WWW are changing almost daily. Just a year ago it really did make sense to call WWW documents homepages: for the most part they looked like static book pages rendered electronically. Even today, however, Web documents are beginning to evolve into much more dynamic objects. It is this emerging global information infrastructure (GII), which will succeed the current Internet and WWW – a computational environment populated by many multimedia and interactive applications, as well as human and computer agents – that will be the focus of our discussions.

Of course, many technologies other than the Internet can and do play important roles in education. Standalone computers run many kinds of useful instructional programs; they surely will continue to be important as machines drop in price even as they increase in power. And, today certainly more educational information is delivered on CD-ROM than through networks like the Internet. Still, we favor the Internet as a unique foundation for education, in preference to other tools, because it will *eventually* include all their functionalities, and more (see Figure 1.). If you omit interaction, the Internet can become instructional TV; if you omit text and other symbolic media, it can mimic two-way video; if you omit multi-casting, it might look like a one-on-one intelligent tutoring system; and the Internet can even impersonate fax, radio, or newspapers.

Figure 1.

The Internet and World Wide Web as a Communication Chameleons

Rooted in relatively primitive network applications that transfer files of text (e.g., ftp), over the past few years, the World Wide Web has added layer upon layer of new communication protocols and document types. Now, you can find web sites that imitate virtually all other communication devices – audio or video, two-way or one-way, broadcast or point-to-point. But are these imitations? Perhaps it is better to view the Internet simply as a flexible new medium that can merge or encompass all old (and new) information technologies.

Below we summarize just a few of the of the many web sites that today (1/96) are chameleons masquerading as other media. We describe the site, the media functions it mimics, as well as examples of the "plug in" or helper applications that permit such mimicry.

Function	*Web site example*
Radio	***NPR***'s site (http://www.npr.org/) includes a subset of their broadcast, including newscasts updated every few hours. ***Net Radio*** (http://www.netradio.net) permits listeners to select different types of music, as well as "talk radio" features, at a click of a mouse. Both NPR and Net Radio use ***Real Audio*** (http://www.realaudio.com/) as a helper application.
Telephone	***WebPhone*** (http://www.netradio.net/ftp.html) provides telephone quality, point-to-point, voice communication over the Internet; WebPhone incurs no long distance charges, much to the consternation of traditional long-distance providers.
Television	Hundreds of web sites already are devoted to commercial TV; most are simply advertising, but several include substantial video. ***PBS***'s "Life on the Internet" http://www2.pbs.org/internet/) was a 13 part video series made available on the Internet. It used ***VDOLive***'s (http://www.vdolive.com/) Internet video technology and servers. ***HyperTV*** (http://www.hypertv.com/) promises to interweave traditional TV transmission and Internet browsing.
Newspaper	Hundred of newspapers are now on line. Some are faithful to their hardcopy versions; others are better designed for the Web. In this regard, The ***New York Times on the Web*** (http://www.nytimes.com) falls about in the middle.
Phone book	***BigBook*** (http://www.bigbook.com/) not only boasts a very complete interactive yellow pages for the whole nation, but also will display a map showing the location of a business, as well as reviews offered by other users.
Billboard	***CyberBillboard*** (http://village.ios.com/~cyber/cbbdesgn.htm) will design and post electronic billboards on the Web for customers.
Fax	There are any number of ways to send a Fax on the Internet; try just printing, say, a Word document to a fax "printer"
Video game	***Broken Arrow*** (http://www.brokenarrow.com/) is advertising for a feature film in the form of a video-game that can be played on the Web.

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Intelligent tutoring systems	***Rebel!*** **is an interactive, exploratory environment for learning history through simulation. It was originally configured as a standalone application, running on a Mac. As discussed later, the system was reconfigured to display to, and interact with, users on any machine connected to the Web.**

While the Internet can mimic more traditional information media, it also offers novel functionalities not found elsewhere – multi-user video games (like "Command & Conquer", http://www.mpath.com/mpath-news.html), interactive soap operas (like "The Spot"; http://www.thespot.com/), or on-line "chat" rooms (like "V-Chat"; http://www.microsoft.com/corpinfo/press/1995/95nov/vchatpr.htm), for instance. Supported by emerging standards like the Common Object Request Broker Architecture (CORBA), we can expect to see an ever-expanding collection of new document formats (now called distributed objects) and communication protocols. These will give rise to more and more products unique to electronic networks – ones that imitate no previous communication medium.

The ability of the emerging Internet to encompass virtually all other information technologies is potentially of critical importance. Discussing how this potential could be realized in higher education is one of the main themes of this paper. The other recurring theme provides a more sober counterpoint to this sunny picture. We claim that information technology – or any profound innovation – leads to a fairly predictable sequence of events as it is adopted in society. First, it is exploited as an *enhancer* or magnifier: it is used to accomplish traditional practices (in manufacturing, services industries, even education) more efficiently or productively. Later, it becomes a *transformer*: it leads to new practices and products, not simply better versions of traditional ones. This shift is usually very slow and rarely smooth. Traditional applications of new technologies can lead to valuable improvements, so there is often good reason to resist fundamental change – early gas-powered vehicles designed to resemble horseless carriages *are* useful. But, in the long run, the technology affords new opportunities that can be much more valuable – cars are *much more* useful. Yet this transformation is not without great uncertainty and great cost, in time, money, and fundamental restructuring – cars dominate carriages only if we build paved roads, provide service stations, and pass laws that govern speed and the transport of goods.

This idea is not new (it parallels the economic distinction between process and product innovation, for example) but will arise often in our discussions. We will see many possible applications of information technologies in higher education. Some relatively traditional applications are attractive in the short-term because they can help cut costs. There is certainly no reason to reject them. But more innovative applications could help solve other important problems in the long-term, even though they may not save money in the short run. The difficulty is that some of these are not just technology

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fixes or "add-ons": they will require that the higher education community think hard about its mission, its organization, and its willingness to invest in change – even in a time of fiscal tightening.

OPPORTUNITIES: KEY APPLICATIONS OF INFORMATION TECHNOLOGY IN HIGHER EDUCATION

Information technologies can impact virtually every facet of higher education, much as they do almost any service industry. We will focus here on the opportunities that appear unique to education. That means many important applications will be ignored; for example, we pass over the different ways technologies already streamline the maintenance of student records, budgeting, payroll, and general administration. There is already a large literature on the costs and benefits to business of computer and communication technologies, and educational applications add few new insights to this field. Rather, we will look at applications of information technologies from the inner missions of higher education outwards:

- First, what tools for learning and instruction delivery can new information technologies promise?
- Next, how can information technologies help provide tools for building instruction?
- Then, can information technologies offer tools for improving decision-making and community-building within higher education?
- And, finally, how can information technologies help connect higher education institutions to industry and society as a whole?

In these discussions we will summarize available data on how technology helps overcome important problems for higher education. But we will also include many sidebars of current or emerging "best practice". Our arguments are illustrated by examples partly because they bring abstract claims to life, but also partly because there is little hard data on what new technologies can really do for higher education.

Learning and Instruction Delivery: Reducing Costs and Increasing Productivity

Most discussions of computers in education look at how new technologies might improve "instruction delivery" – a management theorist's way of saying how teachers teach and how learners learn. As resources for higher education continue to dwindle, therefore, when most people think of information technologies it is usually in terms of how they might reduce the number of teachers needed or cut the time (and money) learners take to acquire skills. A collection of cases in current practice suggest some technologies do indeed help improve productivity in these ways (see Figure 2).

Figure 2.

Information Technology and Cost Savings

Site/Study	*Cost-effectiveness Results*
Distance Learning	
Open University, United Kingdom (1989)	-cost per grad lower than conventional university
Deakin University, Australia (1989)	-cost per student 97% of on-campus student
Indira Ghani National Open University, India (1991)	-cost per student between 8% and 40% of cost at conventional university -student performance rates only 60%
Open University teacher training, Indonesia (1988)	-cost per student about 60% of cost at conventional university
Everyman University, Israel (1978)	-cost per grad estimated at half cost at conventional university
Teacher training at a distance, Tanzania (1979/84)	-costs about half those at a conventional university
National Technological University, USA (1989)	-breakeven point (in per student cost) at 9,000 students in 200 courses
CAI and CBT	
Orlansky and String (1979)	-30% reduction in time to achieve criterion performance using computer-based instruction in military training
Fletcher (summary of 47 studies) (1991)	-30% time savings, 30-40% cost savings, and improved achievement using multimedia instruction
Levin (summary of 8 programs) (1989)	-CAI proved more cost-effective than reducing class size, or extending length of school day -but less effective than peer tutoring
Hall (summary of 8 case studies) 1995	-CBT in business reduced training time from 40 to 80% compared with traditional text-based training -CBT in business reduced training costs from 40 to 85% compared with traditional training
Roberts (1991)	-IBM cut its annual training budget of over $1B by $30M by using CBT
Intelligent Tutoring Systems	
U.S Air Force	-ITS traditionally deliver high student learning outcomes, but at a high price; the Air Force aims to cut development costs by 95% and development time by up to 80% -the result would be an overall reduction in training costs

Current successes are subject to several qualifications. Some cost-savings are modest, others come with hidden prices (for example, high development costs or lower grad rates), and all depend on careful attention to implementation in the classroom. But, though the data are still equivocal, the economic logic behind the view is relatively straightforward. In general, one way to cut costs is to do more with less: hold student outcomes roughly constant (or improving) while displacing labor (staff) by capital (here, information technology). With technology costs continually dropping while labor costs only rise, this trade-off appears a good bet to increase productivity.

Computer-aided instruction (CAI) and computer-based training (CBT) have shown some payoffs along these lines. Such "drill and practice" systems are most frequently found in secondary schools, but also play a role in remedial math, science, and language courses at the collegiate level, as well as in business and military training (see Figure 2). However, as convenient as they might be for self-paced learning, CBT programs do not often yield dramatic cost-savings. Development costs for multimedia courseware are usually very high, often offsetting savings in delivery. Another problem, in some cases, is that the cost of buying a stand-alone computer system for each student is so high that labor costs must fall dramatically before any net savings appear. This may change in the future, though, as powerful machines drop roughly to the cost of a top-of-the-line TV.

Today, distance learning provides probably the best examples of cost-savings that are at least partly attributable to information technologies. In Asia, several studies show distance learning courses run from between 45% to 90% of the cost of conventional college classes, with comparable student performance; costs can drop to as little as 8% of on-campus courses, although completion rates then also seem to dip. The Open University, in Great Britain, one of the first very large scale experiments in distance learning at the higher education level, boasts average per student costs around half that of conventional campuses (see Figure 3). However, a brief examination of its success will show why, at least right now, distance learning can help reduce costs only under relatively narrow circumstances.

Figure 3.

The Open University: Mother of Modern Distance Learning

The best-known example in higher education, and most successful example of its kind in the world, is the UK Open University. Some 40 distance teaching institutions across the world have been based on the OU model. It's methods are well known, but it is worth emphasizing an important aspect that is often misunderstood. Although the OU has developed widely-admired methods for the use of teams in the design and production of teaching resources, mainly paper-based materials, and although it still carries in many people's minds the image of the "University of the Air", it is the UK-wide network of part-time tutors who provide the main teaching that is experienced by OU students. Tutorial support is provided by traveling to quite frequent face-to-face meetings, by telephone contact, and by feedback on written assignments. In a real sense, the formal aspects of studying for an OU degree differ little from those experienced by students on a conventional campus. The cost per student, however, is about half that of conventional campus universities. The OU is now exploring how best to build on its success through the emerging advanced learning technology (ALT), in particular in the use of CMC (computer-mediated communication) for collaborative learning, and in the delivery of its course materials through CD-ROM. (From Mayes, 1994; http://www.icbl.hw.ac.uk/ctl/mayes/paper10.html).

First, the technology must allow many students to be taught at once. The larger the class size, the greater the student/teacher ratio; this drops labor costs and spreads high development and initial technology costs, both leading to productivity improvements. Breakeven points – class sizes where the cost of distance education and traditional delivery are roughly equal – will vary depending, among other things, on the size of technology investment and the course being taught. But its a safe bet, at least for the near-term, that distance learning classes of less than 20 will rarely lead to substantial per student cost reductions. Class sizes at the Open University usually exceed 200. Second, a substantial amount of labor must be displaced by technology. Typically labor is over 95% of class cost, so modest trades of faculty for machines will not substantially change overall prices. This, in turn, means that distance learning works best in relatively "standard" courses – such as math or sciences – where knowledge is relatively well codified, and where, therefore, much knowledge can be embedded in the technology, and hence much teaching can be delegated to it. Alternatively, to expand the range of courses that can be taught at distance, the use of technology should be carefully designed so that expensive labor at least can be replaced by cheaper help. For example, the Open University makes liberal use of tutors, either in person or on the phone. Finally, technology should substitute for labor as simply as possible. As the example of the Open University suggests, most low-cost distance learning does not fundamentally change the learning experience for the student – or teacher. A computer application that promised to play a substantial role in teaching but also demanded broad changes in faculty skills and activities (we will discuss several of these shortly) could actually increase labor costs, even when it seems to guarantee a savings in teacher time.

The bottom line, then, is that today's distance learning technology is largely limited to relatively routine skills and knowledge, taught "en mass", through relatively traditional methods. Most of the best examples actually come from military and corporate training, rather than higher education. For example, large companies such as Ford now contract for distance instruction to help their employees learn how to use tools like spreadsheets, word-processors, as well as specialized equipment. And Hewlett-Packard estimates it saves millions of dollars each year using distance learning to train employees more effectively and more efficiently than with conventional methods. All of which explains why well over half of distance learning now goes on in businesses, not in academic settings. This market is expanding so rapidly that whole TV networks now are dedicated to corporate distance learning.

Internet Impact: Distance learning, cost reduction, and increased access

At least partly to cut costs, almost all higher education institutions on this country are considering distance learning programs, and dozens already have substantial offerings in place. In the future, we believe that Internet will be the most cost-effective way to deliver a new generation of distance learning courses. Many universities are now moving in this direction. By winter 1996, the US Distance Learning Association (http://gopher.usdla.org/home.html) listed several dozen universities with homepages outlining their WWW and Internet-based courseware. At the same time, the World Lecture Hall, a Web site managed by the University of Texas, has become a "virtual repository", organizing links to hundreds of other sites that are making Web-based class materials available to anyone who is interested.

Because the WWW first came on-line only in 1991, these course are all very new, and there is no solid data proving effectiveness Internet-based distance education. But a chemistry curriculum drawn almost at random from the World Lecture Hall[1] illustrates some of the reasons why Web-based distance learning seems very promising, at least "on paper" (see Figure 4). To begin with, emerging Internet courses can include a wealth of material about the class (lectures, exams, assignments), and references to relevant on-line literature (books, programs, tools such as the Periodic Table), all accessible at the click of a mouse on a hypertext link. Each of these sources can be constructed as multimedia documents, including pictures, digitized audio versions of lectures, presentation overheads – even simulations that can be run to give a much more dynamic impression of processes and structures. Full high-bandwidth interactively will be available soon, to support multi-person, multimedia dialogues in real-time. The new generation of Internet-based distance learning courses, therefore, should provide substantially richer learning experiences for students than the current generation. They can mix the graphics and video of instructional TV with a much more intimate style of interactive mentoring than teleconferencing could ever offer.

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[1] Found under the "Chemistry" entries on the World Lecture Hall homepage (http://www.utexas.edu/world/lecture/index.html) on February 4, 1996. The course itself was at Brown University (http://jcbmac.chem.brown.edu/baird/Chem22I/chem22i.html) on the same date.

Figure 4.

Internet-based Distance Learning: Today and Tomorrow.

Chemistry 22C is taught by Prof. James C. Baird of Brown University. The WWW course materials, found indexed under "Chemistry" on the World Lecture Hall includes:

- On-line lecture notes
- Lecture "overheads"
- Digitized audio of actual lectures, which can be played, rewound, replayed
- Homework assignments and answers, updated weekly
- Electronic archives of past final exams and answers
- Pointers to on-line resource material

Students access these different resources just as they do any Web homepage: by pointing and clicking on text links.

While this example is quite complete it didn't include features found in a few other course homepages:

- *Calendar of class sessions:* Often presented as a table, including date of the class and daily topic. The topic description is often hypertext: clicking on it allows access to the material for the class (lectures, overheads, etc.).
- *Virtual office hours:* Some professors included buttons that allowed students to send email to them, or to other students in the class.
- *"Chat" rooms:* In some classes students can login and engage in text-based discussions with other students from the class who also happen to be on at the same time. Faculty also often pre-arrange virtual office hours: times at which they will be logged-on as well.
- *Video and movie clips:* Video clips (usually less than a minute in duration, given current time and space constraints) are sometimes included in Web courseware, for example, to demonstrate complex physical processes.
- *"Live" computer programs:* In an increasing number of Web-based courses, students can run simulations, in addition to viewing more static lecture materials. The simulations run on remote machines, but display on the user's machine, and often permit the student to interact with the simulation and control its execution – for instance, using forms to input simulation parameters.

Web-based distance learning might enhance productivity in higher education in several ways. Most obviously, by providing a more powerful and flexible medium, the Web should enable developers to construct higher quality courseware for a wider range of classes than ever before (see Figure 5, top panel). With richer courseware, classes where computers once replaced only a modest amount of labor might shortly be taught almost exclusively through technology; and in courses where information technology previously had no part, it may play at least a supporting role. All this means that Web-based learning tools, appropriately used, promise to replace more labor, and consequently lower faculty costs.

Figure 5.

Is the Internet the Medium of Choice for Distance Learning?

The Internet's promise for distance learning is based on its potential to provide a flexible and high-functionality medium for delivering instruction, at a cost that is now within reach and steadily dropping.

The powerful functionality is based on several features:

- Two-way interactive communication. The Internet naturally supports distance learning that permits communication from student to teacher (or technology) as easily as lecture from IT to student. Generally, students learn better from interactive courseware than one-way. Of course, if desired, TV-style distance learning lectures can readily be simulated on the Internet.
- On-demand communication protocol. Courseware is accessed on the Internet whenever the user wants it, and from wherever the student plugs in his machine. No need to remember when an instructional show is on, or even to set your VCR.
- Wide communication bandwidth. Recent advances in compression and coupled with innovative ways to use existing infrastructure (new modems that transform TV cable into full-duplex computer connections, and ISDN as well as ADSL for copper phone wire) will make roughly the capacity of two-way video available to most Internet users.

Costs are dropping for several reasons:

- Hardware needed for Internet access is dropping quickly in price. Today you need at least a low-end PC or Macintosh to access the WWW and any courseware on it. Within a few months, "HollowPCs" or "Internet appliances" that permits basic Internet access will be selling for about $500, perhaps even as low as a Nintendo machine.
- Network costs are dropping to zero. Or, more precisely, the cost of using the Internet is low and independent of distance, so it should be just as cheap to access distance learning material from New Zealand as from next door. (This is why more and more people are using the Internet for their telephone service, to the consternation of long-distance phone companies.)
- De facto standards are making it easier to develop shareable courseware. The WWW is rooted in a few document and communication protocols that most homepage builder (or more generally, publishers) currently adhere to. This may not make it easier to build any single distance learning product; but in the long run, it will help the community as a whole create better courseware.

But less visible features of Internet-based distance learning may have even more dramatic impacts on productivity. It is natural to assume that if courseware built on the Web is richer than previous distance learning products, it might also be more costly to deliver. Natural, but probably wrong. Although few realize it, the Internet is not only a better medium for learning and interaction – permitting on-demand learning, and two-way dialogue – it should also be a *cheaper* way to deliver instruction (see Figure 5, bottom panel). Providers of corporate training already have figured this out. For example, they are quickly trading their old on-demand video systems for more flexible and less expensive "Web TV", which uses Internet-style private networks to deliver full-motion video to hundreds of viewers at once, at the click of a mouse (see Figure 6).

Figure 6.

The Internet as a Higher-Functionality, Lower-Cost way to Deliver Video-On-Demand

VIDEO ON THE INTERNET

In some ways, Web TV resembles on-demand video systems that some companies already use for training videos and inspirational messages from above. Indeed, it might even be better. One failing of corporate video systems has been the need for a user to download the video from an archival computer (known as a server) store it on the receiving computer (the client) and then "decompress" it before being able to play it back with special viewing software – a process taking anything from ten minutes to a few hours. With Web TV it should be possible simply to click and watch.

(Economist, January 20, 1996; p. 83.)

Schools and homes can expect similar benefits, even if they cannot afford the high-capacity LANs of big business. High-bandwidth yet low-cost connections to the WWW will soon come in several flavors. Already today most homes could access the Internet on the cheap through ISDN phone connections, providing about 5 to 10 times the effective bandwidth of ordinary phone lines. More interestingly, recent successful trials of cable modems mean that very high-speed Internet connections, exploiting under-used TV cable capacity, will become available shortly, and should cost little more than standard cable service (see Figure 7). If so, the much heralded but never realized "500 channels of cable TV" finally could turn into something really useful. And, because they require no new and costly infrastructure development, wireless connections may be the most promising of all. In short, the technical problems facing the installation of inexpensive wide-bandwidth Internet connections are all but solved; the policy barriers, however, loom large, as we discuss in subsequent sections.

In addition to reducing educational costs, the shrinking price of delivering Internet-based distance learning should help address other problems of higher education. For one thing, Internet-based distance learning could be conveniently accessible to many different kinds of learners. Part of this improved access simply means putting more people in touch with more learning resources. A new wave of cheap "Internet appliances" (dumb terminals dedicated to web browsing) should bring Internet access within almost anyone's budget (anyone who can afford Nintendo should be able to afford the WWW).

And once on the Internet, all resources are equally inexpensive to browse, whether they happen to be on a homepage next door or thousands of miles away. Equally important for improved access, though, is the ability of Internet distance learning to reach consumers at "any place and any time". This flexibility will be especially important, for example, to workers who want to "retool" skills at night while working during the day.

Figure 7.
Internet Access at the Cost of Cable TV Connection

CABLE MODEM TRIAL DEEMED SUCCESSFUL

A marketing trial of high-speed cable modem service conducted by Time Warner subsidiary Paragon Cable has shown virtually no churn among its 200 test participants and the waiting list is still about 300 customers long. "There's a real business here," concludes Paragon's general manager. Elmira, NY cable customers paid a $30 installation charge and a $25 fee to receive Zenith modem units that provided access to a local database and to the Internet. Building on their success, Paragon plans to take the service commercial in Elmira at the end of March, and Time Warner is scouting out other likely locations for pilot programs. (Broadcasting & Cable 29 Jan 96 p48)

Reflection: Death of distance as a barrier to learning

At the broadest level, we believe an Internet style of learning or instruction delivery will be so common that it makes little sense to view distance learning as a special case. Since Internet and Web tools will continue to drop in cost and increase in functionality for the foreseeable future, over time technology should displace more and more faculty labor. Further, what labor cannot be displaced will at least not have to be nearby – the Internet can connect students with faculty and peers as easily as it connects learners with multimedia documents. Eventually, then, most learning will be distance-independent, and the special cases will be those that are "geographically bound".

Perhaps more to the point, distance learning should be viewed as a common tool in higher education, not an a separate option, and an esoteric one at that. This means most courses should be designed to use distance learning in some capacity, sometimes liberally, sometimes sparingly, and often in a variety of capacities. Already there are a wide range of experiments in distance learning, and they come in many flavors, rather than all fitting one mold (see Figure 8). In all cases students and teachers rely on electronic and hardcopy media, rather than face-to-face contact, for at least some of their communication. But the degree to which direct interactions are replaced can vary significantly. Telecommunications are sometimes little more than an add-on to classroom lectures; conversely, taped lectures may be the centerpiece of instruction, with face-to-face tutoring acting as a supplement; in yet other cases all discussion happens at a distance. Less obviously, examples also differ in the bandwidth of communication, as well as the degree of interactivity. Early distance learning courses (through postal mail) trafficked only in text, and a single interchange required days, if not weeks – not at all interactive by today's standards. Videotaped lectures distributed from a centralized source offer much greater bandwidth, but no more interactivity; on the other hand, email discussions between teachers and students are highly interactive, but narrow in bandwidth. Some of newest Internet-based distance learning enjoys both broadband multimedia connections and real-time interactions, often not only linking faculty with students, but students with one another, and with shared online resources. While earlier distance learning models delivered knowledge from a centralized teacher or "server" to students through narrow, slow, and separate connections, newer ones look much more like an electronic community, tying together students, faculty, and distributed tools in a rich, speedy web of electronic contacts.

Figure 8.

Near and far: the many flavors of distance learning

There is no single obvious way to order courses from light to heavy users of distance learning technology. Some courses, for example, offered exclusively at a distance (no face-to-face interaction) still make less use of telecommunication connections than classes that also include some direct contact. Our ordering is roughly from courses that provide narrow connectivity, overall, to those that provide rich interactions.

The list is only illustrative: many distance learning courses already exist that mix and match features and functionality in ways we do not include here.

Features and Functionality	*Examples*
-low bandwidth, non-interactive technology; no face-to-face contact	-Pittman (1840) correspondence courses on shorthand
-high bandwidth, non-interactive technology; no face-to-face contact	-The Teaching Company (see Figure 11) video and audio tapes, augmented by written course material
-low/mid bandwidth, non-interactive technology; some face-to-face contact	-early courses from the Open University (see Figure 3), mainly based on paper materials, telephone and face-to-face tutoring
-high bandwidth, non-interactive technology; some face-to-face contact (tutoring supplements distance learning)	-many corporate training courses using "Web TV" (see Figure 6) that are centered on on-demand multimedia courseware, but also include on-site discussions
-high bandwidth, non-interactive technology; extensive face-to-face interaction (distance learning supplements traditional)	-many satellite- and TV-based distance learning courses, where classes are planned around regularly scheduled broadcasts -some World Lecture Hall classes, where courseware is put online as an adjunct

-high bandwidth, interactive technology; some face-to-face contact (tutoring supplements distance learning)	-Some asynchronous learning courses (see Figure 9), where students nearby campus may come to on-site tutorials
-low bandwidth, interactive technology; connectivity among students and distributed resources, as well as teachers; no face-to-face contact	-educational MUDs or MOOs (see Figure 10), where collections of learners (mentors and students) engage in text-based dialogues in real-time and construct textual "worlds".
-high bandwidth, interactive, technology; fully connected community (teachers, students, resources, and experts); no face-to-face contact (or optional)	-newer Internet-based course from the Open University (http://cszx.open.ac.uk/zx/), where face-to-face tutoring can be replaced by online tutoring and email -many courses offered at virtual universities like Athena (see Figure 27)

With so many variants, it is no surprise that what makes an application of information technology an instance of distance learning is becoming less and less clear. Courseware like the chemistry curriculum in the World Lecture Hall, for example, might be used in a distance learning class; but as a matter of fact, right now it is simply on-line material for an on-campus course. Individual students, though, may turn it into a "virtual" distance learning course, simply by skipping lectures and labs and relying on the rich web documents to compensate for reduced in-person contact. These kinds of individual experiments, which probably have gone on informally for decades, now are leading to large scale studies that will try to gauge the importance of distance as a barrier to learning in technology-intensive courses (see Figure 9).

Figure 9.

Does distance matter in Asynchronous Learning Environments?

The Alfred P. Sloan Foundation is funding research on asynchronous learning networks (ALN) as part of their Learning Outside the Classroom program (http://w3.scale.uiuc.edu/education/ALN.new.html). Courses are used by students at varying distance from campus – living on campus, within commuting distance, or very far way. Two of the questions being examined by different projects are: (i) how well do students learn as a function of distance from the physical classroom?; and (ii) how do students' learning practices differ as a function of distance?

It is useful to view this increasing freedom from spatial location in terms of the progressive "unbundling" of teaching functions in higher education as educational technologies have changed across time. Centuries ago, when knowledge was conveyed exclusively through an oral tradition, location was everything. With the advent of written texts, students were freed from the need to attend lectures (logically, but not always

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legally); however, other important functions including tutoring, counseling, and evaluation remained essentially face-to-face activities. Now, just as books (and cars) weakened the links between distance and learning in the past, today new information technologies can virtually break them. Since the Internet can connect students with teachers as easily as they connect students to course material, tutoring and counseling can be (and are) done through email and real-time chat rooms (see Figure 5). As reference materials increasingly become available in digital form, students similarly will be freed from proximity to libraries. Evaluation and assessment also can be done at distance. Written products, like essays, already are created routinely with word-processors; sending them across a network for grading can be easier than printing them and walking them into a professor's office. Multiple-choice as well as short-answer tests have been computerized for years. In a pinch, even timed, closed-book exams could be conducted using simple key-stroke logging or more sophisticated Internet video products like CU-SeeMe http://cu-seeme.cornell.edu/) for surveillance. Again, the point is not that learning should be conducted at distance, just that creative applications make distance less and less of a barrier to learning. The challenge will be to discover the most effective applications of distance learning technology, and to blend them together with more traditional face-to-face transactions.

Learning and Instruction Delivery: Increasing Quality and Productivity

While many applications of information technology in education try to reduce costs, others focus on the "output" side of the productivity equation, helping students learn more, or better, or to learn new skills – ones rarely included in higher education curricula. A collection of examples (see Figure 10) illustrate information technology applications could lead to better learning and teaching outcomes several ways.

Figure 10.
Information Technology and Quality Learning.

Computer-based applications that change learning qualitatively come in various types. We order these, very roughly, from ones that help students learn concepts more effectively to ones that change the kinds of ideas students learn, and how they learn them.

System/Study	*Quantitative/Qualitative Learning Results*
CAI and CBT	
Fletcher (meta-analysis of 47 studies) (1989)	-.50 standard deviations improvement in achievement (IVD technology, averaged across higher education and military training)
Kulik & Kulik (review of many studies and 12 meta-analyses) (1994)	-overall small increases in learning, across academic, adult learning, and training settings (CBT technology)

The Teaching Company (video and audiotapes) (1996)	-as of May 1996, mainly testimonials about dramatic learning enhancements attributable to use of "superstar" tapes
Intelligent Tutoring Systems	
SHERLOCK (Katz, Lesgold, Eggan & Gordin, 1993)	-provides the equivalent of 4 years of on-the-job training in electronic troubleshooting in 20 to 30 hours
ACT tutors (Anderson, Corbett, Koedinger & Pelletier, 1995)	-30 to 60% faster learning of programming skills, 30-40% higher scores on tests -one grade level (e.g., C to B) improvement in geometry
Interactive Learning Environments	
Apple's Classrooms of Tomorrow (ACOT) schools (Dwyer, 1994)	-studies show students wrote better, completed units in math more rapidly -by the end of 4 years, students changed how they did work, freely employing inquiry, collaboration, and general problem solving skills
Collaborative visualization (CoVis) project (Gomez & Gordin, 1996)	-young students were able to acquire sophisticated understanding of climate and global warming -they were also able to use high-tech visualization tools, engage in open-ended inquiries, and learn collaboratively
Massively parallel microworlds (Resnick, 1994)	-young students were able to learn about complex distributed systems using simulation models run on parallel machines -they were also able to learn general heuristics for modeling decentralized systems
MUDs, MOOs, and MUSEs multi-user real-time virtual realities (as of 1996, most still text-based "chat" rooms, but an increasing number on the Web have graphical interfaces)	-most results are anecdotal, but broadly: MUDs may help learning of: -academic skills (programming, reading, typing, writing) -metacognitive and generic skills (scientific method, learning to learn, help seeking) -personal and social skills (motivation, collaboration, trust)

Some of these applications rely on distinctly cutting-edge technology, making lavish use of multimedia and engaging in students in highly interactive discussions. However, other ideas are surprisingly simple. For example, The Teaching Company (TTC) thinks that the video and audiotapes it offers can help college students improve grades in everything from history to psychology to physics. Of course, these lack the interactivity of a good tutoring session, but TTC is gambling that the quality of their tapes will more than compensate: the lectures are delivered by elite "superstar" faculty in each field, not by merely competent professors.

Some very positive reviews of these products (see Figure 11) may be too optimistic. However, it is clear that, in the future, Web technology could make educational packages featuring superstar instructors easier to develop and more broadly accessible, perhaps leading to significant improvements in teaching and learning productivity. Imagine, for example a course built around master lectures, digitized and put on-line, and combined with complementary assignments, projects, tutorials, and group discussions – like those already found in World Lecture Hall courses. Taking this course through the Internet might not be quite the same as being there in person; but to attend in person you need to be a student at MIT, Stanford, or a similarly elite and pricey institution. On the other hand, for less fortunate students such an on-line course could be better than an in-person course offered by a second-tier university. Here, as in other areas, information technology might lead to improvements in productivity by making truly great practitioners and their performances – not merely gifted ones – available to almost everyone.[2]

Figure 11.

On-line superstar teachers: Goodbye to the merely good?

The Teaching Company is a for-profit business that offers more than 60 audio and video courses on a wide range of academic subjects, from science to philosophy. Most are at the college level. Their main selling point is that lectures (the courses are in very traditional delivery formats, with little support material) are taught by a "dream team" of "superstar" teachers. Almost all have first-rank U.S. university affiliations. While The Teaching Company offers no solid evidence of student learning (in fact they provide no tests or accreditation) they do pepper their brochures with testimonials from the likes of Ted Kennedy, Orin Hatch, and the Los Angeles Times.

While replicating outstanding teaching *performances* on video might lead to improvements in learning productivity, a much more ambitious approach is to try to capture the *reasoning* of teachers in software. Of course, this cannot be done just by pointing a camera at a smart talking head. Rather, the process of developing so called "intelligent tutoring systems" (ITS for short) begins with an expert system – a collection of heuristic rules – that is capable of answering questions and solving problems in a given subject matter. For instance, the expert system inside a good calculus ITS would be able to solve arbitrary symbolic integration problems, and do so in a way that roughly approximates how an "ideal" human mathematician would reason. The expert system in an ITS is often supplemented with a "student modeling" capability, which can examine a student's reasoning, find the exact step at which he or she went astray, try to diagnose the reasons for the error, and even suggest ways of overcoming the impasse.

The potential value of such highly intelligent systems is obvious. Indeed, for decades the idea of supplying students with their own automated tutor, capable of tailoring learning experiences to students' needs at a fine-grained level, has been the "holy grail" of teaching technology. With good reason. Many studies have shown that one-on-one tutoring is one of the best ways to learn. And, as the examples in Figure 10 demonstrate, for a few academic subjects ITS have nearly matched the capabilities of their human tutor counterparts, helping to raise students scores a letter-grade or more.

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[2] See, for example "The Economics of Superstars" by Sherwin Rosen for an economic analysis of how information technology makes great performances widely available, increases the wealth of the elite (at the expense of the gifted) and therefore shrinks the number of people that can make a living providing some information services to a small contingent. Rosen claims that this not only applies to entertainers and sports figures, but (to a lesser extent) to lawyers and business executives, whose range of influence and availability is expanded by modern telecommunications.

However, while such systems show that ITS can raise the output side of the productivity equation in education, their successes to date are very limited. Because they try to embed detailed human reasoning skills, both in subject-matter areas and in teaching expertise, they rely on advances in cognitive theory and software engineering. But today we only have a detailed understanding of cognition for a very few well-defined subjects; consequently, ITS currently are confined to relatively simple parts of algebra, geometry, computer programming, physics, and other sciences. In higher education, then, ITS probably would be most appropriate in basic freshman and remedial classes. And, needless to say, even in these subjects, automated tutors come nowhere near to mimicking superstar teachers. On the contrary, ITS are frequently called "brain-damaged" by most computer scientists – their developers included. Over time, though, ITS will continue to get smarter and smarter. Buttressed by advances in cognitive science, they will capture an increasing share of human teaching expertise, and they will extend to a wider range of subjects. However, all evidence suggests progress here will be slow. While the speed of computer hardware continues roughly to double every two years, the intelligence of computer software – however you measure it – creeps ahead at a snails pace.[3]

But this does not mean information technology is destined to play only a minor role in helping improve the quantity and quality of learning in higher education. It just means that some of the most obvious ways, where technology attempts to partially replace faculty as lecturers or tutors in traditional classroom setting, may not be the most promising approach, at least in the short run. A glance back at Figure 10 suggests that some of the most successful applications of information technology follow a very different principle: instead of mimicking human tutors, they provide rich simulated environments that enable students or trainees to practice skills very intensively.[4]

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[3] Well publicized successes of "man over machine", like Deep Blue's recent win over world chess champion Gary Kasparov are false counter-examples. Kasparov lost only one game en route to winning the match. More to the point, Deep Blue's performance relied almost strictly on fast computer hardware. The program uses brute force searches, and "understands" virtually nothing about the way humans play the game. It is just this kind of understanding that automated tutors must possess if they are to help humans learn.

Flight simulators were the first examples of such learning environments, and they are still perhaps the most compelling ones. For decades they have been singularly effective technologies for improving the quality of pilot training. In the protective environment of a "virtual" cockpit, pilots can perfect difficult maneuvers, trying them over and over, without fear of the deadly effects of a real-world mistake. SHERLOCK (see Figure 10), in spirit a descendent of these early simulators, demonstrates similarly impressive outcomes: students can learn electronics troubleshooting and fault diagnosis skills in less than a tenth of the time they previously required. While SHERLOCK includes some important coaching supports, the basic reason why trainees acquire skills so rapidly is simply that the system can present students with simulated problem situations that arise only rarely in real world – for SHERLOCK, troubleshooting the complex hardware that diagnoses faulty F15 avionics. Trainees do not learn these troubleshooting skills very quickly in the field because problems that might foster new knowledge naturally occur, say, once every few weeks; using SHERLOCK such problems can be made to order every few minutes, if necessary. More generally, this and other "virtual" worlds rely on the fact that one of the most powerful ways to learn is by doing; but learning-by-doing only works well if the world cooperates by providing the learner with a large number of practice cases, and ones suitable to the learner's current level of expertise. In situations where the real world cannot be easily controlled or does not readily cooperate, computers can now provide rich simulated worlds, at an arbitrarily high degree of fidelity, that can be controlled with the click of a mouse.

Such environments seem promising tools for training, but can they work in higher education? While it is relatively easy to imagine how simulated worlds might be useful in concrete subjects like electronics or even physics, it is less obvious how simulations would help in abstract or symbolic disciplines such as history, philosophy, or the social sciences. However, some innovative systems already are already pointing the way. For example, CoVis (see Figure 10), Rebel! (see Figure 12), and even strategy games such as SimCity, are built on top of complex computational models that capture key features of the real-world dynamic systems that underlie policy decision-making, weather, and historical processes. True, these models do not simulate concrete physical systems; but methodologies like systems dynamics demonstrate that at an abstract level many "conceptual" systems also comprise cause-and-effect relationships among a collection of variables. What a new generation of simulation-based learning environments are doing, in essence, is to combine computational models of such processes with highly graphical and easy-to-manipulate "visualization" front-ends. Collectively these give the learner a virtual world in which many "what if" experiments can be performed. In theory then, just as SHERLOCK provides trainees with a large number of rich avionics cases, these simulations might present learners, say, a series of hypothetical history scenarios, some of which may have analogs in real historical events, and some not. These technologies appear very interesting, but they are also very new. Whether they can lead to the dramatic gains in the quantity of learning we find with SHERLOCK remains to be seen.

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[4] Interactive and simulation-based learning environments like the ones we discuss here are certainly not the only alternative to ITS and systems that try to be "smart" or human-like. A few listed in Figure 10, take different approaches; for example, some offer new "power tools" for collaborative learning.

Internet impact: Turning expensive stand-alone systems into cheaper distance learning technologies

Some of the applications that promise to help raise educational productivity by improving student learning, rather than by cutting costs, are already network-based systems. In CoVis, for example, students use the Internet to communicate with distant mentors, collaborate on projects with peers, gather data from remote sites, and talk with experts in atmospheric and environmental sciences (see also Figure 13). But many of the cutting-edge applications are stand-alone systems that run only one or a few computer platforms. One might work on a Macintosh but not a PC, for instance. Even worse, since many of these systems are still research prototypes, they may run only on relatively high-end machines (Sun Workstations, or even supercomputers, for example). All this would seem to mean that some of the most interesting new information technologies for higher education will, for the foreseeable future, either be inaccessible to most students, or prohibitively expensive to for schools or students to acquire.

Not necessarily. One way around this problem, again, exploits the Internet and the WWW. It is already possible for standalone software systems to piggyback on the near-standard protocols for creating World Wide Web documents. In doing so, these systems can be made available very widely and relatively cheaply.

As anyone who uses the WWW knows, unlike most software, Web browsers and servers run on a wide range of machines. The considerable complexities of making key languages (like HTML) and protocols (like HTTP) de facto standards are hidden from the average user, who can happily create documents that will appear on any machine roughly as they look on his or hers.[5] Technically, only WWW documents enjoy this relative machine independence. However, using existing scripting languages (CGI) that enable programs to be initiated on remote machines and new homepages to be created and loaded on the fly, it is possible to turn almost any piece of educational software into a distance learning application. (See Figure 12 for an example of how we turned Rebel! into a Web-based history simulation that could be run on one (high-end) machine, but displayed on a variety of other (low-end) ones.)

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[5] The universality of Web standards like HTML and HTTP are more fragile than they might appear. Even the simple current versions of these protocols do not run on all machines. Future versions threaten to be even less general. For one thing, different groups are extending the basic standards in many incompatible directions; for another, the pressure to develop highly interactive web objects quickly is speeding up the pace of innovation, which works against the slow processes of achieving a broad consensus standard. That said, the current HTML and HTTP protocols are far closer to a universal standard for complex computational objects than we have seen before.

Figure 12.

Transforming Rebel! from an isolated application to Web-distance learning tool

Rebel! is an interactive, exploratory simulation environment for learning history, in particular the American Revolution, by playing "what if" games (e.g., "What if the British had sent over more troops?"). Using it as a standalone system, students start the simulation, then set certain parameters (to operationalize their questions), either by loading "scenarios" that define collections of values, or by changing them individually. Next, the system runs, and, as simulation time steps forward, the student views the virtual world unfold in a series of graphical depictions of simulation state changes. At any point the student can interrupt the run, and click interface buttons that help give them a better understanding of cause-and-effect: what was happening, and why.

We transformed Rebel! from an isolated simulation (running and displaying on the same machine) into a distributed one (running on a *remote* machine, and displaying on a *local* one) using the following procedure.

- The initial homepage shows, on the local interface) a picture of the initial *Rebel!* interface (saved as a gif file, referenced in the html code for the page).
- The initial page also includes a "Begin" button, which, which clicked, triggers a script that causes Rebel! to begin running on the remote machine; it also invokes a new html page -- the initialization page.
- The initialization page allows the user to select from pre-existing scenarios, and set values for specific parameters. When the form is complete, the user clicks the "Run" button. This invokes a script ships all the initialization data back to the remote machine, where *Rebel!* process is waiting for it. On the remote machine, the simulation parameter values set by the user on the local machine then are read in, and the remote Rebel! simulation run actually starts.
- As the simulation runs it periodically updates its state and writes (actually creates on the fly) a new html document (representing the simulation state), and puts it into the *output file*, to be displayed on the students local machine.
- Http protocol on the local machine polls the remote machine at regular intervals looking for an updated interface document in the *output file*, and loads it when necessary. .
- "Stop" is always one option on each reloaded document" If the student selects the "Stop" button, a script writes instructions to a *user input file* on the remote machine that causes the remote simulation to suspend.
- Throughout the run a similar protocol enables the user on the local machine to interact with the simulation on the remote one: the simulation always looks for messages in the *user input file* to modulate its behavior, and the Web browser on the local machine always updates its image of the simulation interface by reloading the *simulation output file*.

The cleverness needed to turn isolated software into shareable distance learning systems on the WWW might be of technical interest to some readers (certainly the exercise has fascinated the authors). But such technical subtitles miss the key point of the example: already, the Internet and WWW permit high-powered applications that run only on high-powered machines to be accessed by students who might have available only low-end machines – and virtually any kind of low-end machine, not just ones that the original application developer envisioned.

The future looks even more promising, on several scores. First, as recently noted, ultra-cheap Internet appliances should bring down access cost even further. Second, the

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protocols needed to make products widely shareable across the Internet, using almost any hardware platform, are quickly falling into place. Tricks now required to turn the WWW into an interactive medium will soon lose their interest, primarily because new Web tools for building "live computational objects" (it is misleading to call them documents any more) will soon provide primitives that make this kind of interactivity easy to achieve rather than a challenging problem to solve.

All this may mean that higher education can have its cake and eat it too, at least a bit. Most of the current cutting-edge information technology applications we reviewed promise to help students learn better or faster, or both. Improving educational productivity in this sense is clearly an important goal for higher education. But, until recently, this goal seemed at odds with others: reducing the cost of delivering education, and increasing access to education by an increasingly diverse population of students. Without question, in the future most applications of technology in education that offer exciting possibilities for transforming teaching and learning will continue to be developed in corporate and university research settings on high-end machines. And these will probably remain expensive, well beyond the means of almost all students and even most higher education departments and computer labs. However, high-bandwidth networks, coupled with increasingly standardized software languages and communication protocols, and with ever-cheaper Internet terminals, should bring these cutting-edge applications within reach of learners and teachers that do not have access to the newest and fastest technologies.

This does not mean poor students will enjoy all the same access to technology-based learning as wealthy ones, of course. There will always be computers that offer more functionality at a higher price. And even if high quality educational materials could be accessed by anyone on any machine at any time, nothing right now prevents providers from metering this access and charging whatever the market will bear. (Nor, necessarily, should providers be prevented: these and related policy issues will be examined shortly.) The point, however, is that information technology by itself will no longer be a significant barrier to access; if anything, the WWW and Internet should be a force towards greater access and equity.

Reflection: Many interesting options, many hard choices

Certainly, information technologies do more than provide better tools with which to deliver instruction and learning materials in higher education, but such tools still dominate the field of educational technology. We have discussed (or at least pointed to) a wide range of these applications, focusing especially on ones that exploit the WWW, or could do so. Stepping back from the many specifics, several general points are in order.

First, it should be obvious that information technologies offer many different ways to improve instruction delivery, not just one. Even looking just at distance learning, there is a rich set of options to pick from. Selecting among the different choices demands attention to the (often implicit) educational goals the technologies address. Some might help higher education institutions reduce costs; but others look better suited to increasing access to educational resources, or increasing the quantity, quality, or speed of student learning. Overall, the proliferation of Internet and WWW resources should steadily bring down the cost of all educational software products and services. Yet, some will be relatively more costly than others; and a few still will be very expensive for the foreseeable future.

In general, then, it is a mistake to assume information technology provides one or a few ways to improve learning and teaching, and it is equally wrong to believe technology applications will affect a just single educational goal, cost-reduction. A third assumption, probably more widely believed, is also wrong: that information technology is mainly a vehicle to enhance educational productivity.

Look back for a moment the last few information technology applications described in Figure 10. While some, such as SHERLOCK, clearly intend to help speed-up learning, or improve learning of well-defined subject areas, it is much less obvious how others are trying to improve educational productivity in any simple sense. Instead, they are generally trying to transform the *processes* and *products* of learning. For example, they might exploit new visualization technologies to enable junior students learn about complex systems that previously only grad students found comprehensible; and they might foster deeper understanding through inquiry-based learning rather than traditional lectures, or through collaborative learning methods that simply never existed prior to high bandwidth networks. In short, here information technology is a driver of educational reform, not of productivity enhancement – unless productivity is redefined to include a wide range of qualitative changes, not just quantitative improvements.

That these applications *transform* processes and products of learning more than *enhance* productivity has several implications for their adoption, implementation, and costs. Consider how many different facets of an educational context might need to change to realize the potentially impressive benefits of such applications, according to their developers (see Figure 13). Clearly, the technology itself – the tools actually used by students in learning – is just the tip of the iceberg. Other possible changes range from the roles of teachers, to methods of evaluating learning, to deeper philosophical views of how learning happens and what constitutes knowledge. All this is roughly consistent with a simple rule we have distilled from our own research in developing and implementing educational technology: if a technology fits into an existing an existing educational process and tries to enhance existing educational products, you spend 75% of your time developing the technology and 25% worrying about all other implementation issues; if a technology tries to transform educational processes and products, you spend 75% of your time attending these non-technical, often complex, and frequently invisible changes in institutional practice and structure.

Figure 13.

What it might take to make CoVis work

Here is what the CoVis researchers say about their project and goals (http://www.covis.nwu.edu/info/CoVis_OV.html):

"Traditionally, K-12 science education has consisted of the teaching of well-established facts. This approach bears little or no resemblance to the question-centered, collaborative practice of real scientists. Through the use of advanced technologies, the CoVis Project is attempting to transform science learning to better resemble the authentic practice of science. ...

The CoVis Project will explore issues of scaling, diversity, and sustainability as they relate to the use of networking technologies to enable high school students to work in collaboration with remote students, teachers, and scientists. An important outcome of this work will be the construction of distributed electronic communities dedicated to science learning.

Participating students study atmospheric and environmental sciences through inquiry-based activities. Using state of the art scientific visualization software, specially modified to be appropriate to a learning environment, students have access to the same research tools and data sets used by leading-edge scientists in the field.

The CoVis Project provides students with a range of collaboration and communication tools. These include: desktop video teleconferencing; shared software environments for remote, real-time collaboration; access to the resources of the Internet; a multimedia scientist's "notebook"; and scientific visualization software. In addition to deploying new technology, we work closely with teachers at participating schools to develop new curricula and new pedagogical approaches that take advantage of project-enhanced science learning. "Collaborative Visualization" thus refers to development of scientific understanding which is mediated by scientific visualization tools in a collaborative context. The CoVis Project seeks to understand how science education could take broad advantage of these capabilities, providing motivating experiences for students and teachers with contemporary science tools and topics."

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Here are a few of the transformations in traditional classroom practice needed to realize these goals:

- *Philosophy of learning and teaching.* Learning is no longer viewed as absorbing information but constructing meaning (instructionism vs. constructionism); inquiry rather than drill-and-practice is the preferred means of acquiring knowledge; and visualization as well as text-based comprehension is a key approach to understanding.
- *Teachers' roles (and training).* Teachers act as mentors and guides to information resources, rather than as lecturers and sole sources of knowledge; they also must be fluent with new collaboration and visualization technologies.
- *Students' tasks.* Students learn mainly through inquiry structured by projects; most projects are done in collaboration with other students and external experts (through network connections) rather than individually.
- *Curriculum structure.* Curricula are organized around authentic projects that embed long-term tasks comparable to those tackled by professionals in the field; small-scale tasks, such as solving a collection of algebra questions, are largely abandoned..
- *Classroom organization.* Classes are organized conceptually and physically by projects and computer networks. The networks connect students and their tasks to external databases and experts who are sources of information, support, and commentary, as they conduct their inquiries. Students spend little time engaged in paperwork at desks.
- *Evaluation strategies.* Authentic evaluation strategies replace traditional ones; students are evaluated on the basis of the quality of their projects, rather than their scores on short-answer or multiple-choice tests.

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If anything, our "75/25" rule understates some of the complexities and costs of integrating cutting-edge applications into the classroom. True, it does suggest that deep institutional changes might be necessary to make best use of some information technologies. However, it also seems to imply that we can anticipate the best ways to use these tools in advance, and that the biggest challenge will be to change the educational system to reflect what we know we need. This is probably far too optimistic. Who would have imagined a decade ago that visualization technologies or simulated worlds would open up new educational experiences to learners? By the same token, it is extremely difficult to predict with any confidence what new and interesting applications of information technology for learning will surface over the next decade, or to imagine the kinds of institutional changes that might be necessary to best exploit these new tools.

This is not to argue that all good applications of the Internet and WWW to deliver education are shrouded in mystery. Again, there will be many options to choose from; some applications – perhaps simple Internet distance learning tools and the next generation of ITS – may continue to fit well into existing higher education structures and to reduce costs or increase teacher productivity; others may give rise to new structures and cause us to rethink our ideas of educational productivity; and a few may transform learning in completely unexpected ways. Shortly, we will see additional examples of unexpected applications of information technology. Later sections follow up a few policy implications of this uncertainty.

Improving the Creation of Instruction and Learning Materials

Information technology provides new options for instruction delivery, but that is not the only important role it can play in higher education. Aside from enhancing administrative and research productivity and streamlining test-taking (which we do not dwell on here) new technology can also help create new instruction and learning materials (what's the point of electronic delivery if there is nothing to deliver?). In turn, these new methods and tools can address some of the key problems of higher education, including responding more nimbly to changes in demand, and competing with new providers. As before, information technology provides several ways to improve the development of instruction and learning materials; and, also as before, some options are relatively simple extensions of current methods, while others are more novel.

Expanding traditional methods of production

The traditional pipeline for producing educational materials (and intellectual artifacts in general) consists of many parts, but four are central. To simplify slightly: authors create documents; publishers mainly manufacture and market copies of these products; libraries primarily acquire, store, and distribute copies to the nearby community; and readers consume them. These groups have played relatively stable roles in the publication process for decades, even centuries. However, information technology is changing these roles; and, equally importantly, it is transforming the copyright and intellectual property right laws that underpin relationships among the players.

The simplest view of this change argues that new information technologies will reduce, perhaps even eliminate, the need for publishers and libraries. Historically, publishers and libraries have been essential intermediaries that enable authors and audiences to reach one another. Authors rarely possessed the tools, skills, and capital necessary to typeset their books, calculate the size of production runs, or coordinate with vendors. On the other hand, individual readers (especially students and researchers) rarely could afford to acquire vast libraries of literary holdings. Publishers and libraries traditionally have met these needs. But as educational products become increasingly digital and networked, all this may prove unnecessary, at least from a technical perspective.

Today, academic research provides the most impressive examples of how higher education is exploiting information technology to simplify the document production pipeline. (This is hardly surprising: as we have already noted, the Internet was an active tool in scholarly research long before it played a significant role in instruction.) Members of several research communities in medicine, mathematics, and the physical sciences now publish their work, at least in "preprint" form, on the Internet (see Figure 14). The first electronic academic journals came on-line in 1991; by mid-1995 more than 300 populated cyberspace.[6] Although individual publishers have been quick to add additional organization and decoration, in its simplest form, many of these works comprise a collection of homepages that can be read at a distance using virtually any Web browser. Providing you know the Internet location of an on-line journal, accessing the current issue (if there is one – some electronic 'zines simply accumulate publications over time) is simply a matter or entering the address and reading what comes up on your screen.

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[6] For an overview of electronic journals, links to many sites of and articles on electronic journals, as well as some current (as of Spring 1995) statistics on their growth, see McEldowney, P. "Scholarly Electronic Journals - Trends and Academic Attitudes: A Research Proposal" (url: http://poe.acc.virginia.edu/~pm9k/libsci/ejs.html)

Figure 14.

Scholar as publisher: Making research directly available to readers across the Internet.

Researchers have made the transition from print to bits in several steps – a process that is still continuing. In 1991 scientists at Los Alamos National Laboratory tool the first step by setting up a service to distribute "e-prints" (electronic versions of paper preprints) over the Internet. Since then their service as grown to handle over 40,000 requests per day (see http://xxx.lanl.gov/).

The next step is to put the whole journal review and publication process. Researchers now submit their articles by email or the Web, editors send them electronically to reviewers, and the final revised versions are published in an electronic journal. As a result, turnaround times for publication are now a few weeks, not months; and subscription rates are usually a fraction of paper journals, and sometimes free. By 1995, McEldowney had found over 300 electronic journals.

A third step is just now being taken. Some sites that began as single journals are adding new publications and new functionality. BioMedNet (http://BioMedNet.com/BioMedNet/biomed.htm) , for example, offers researchers a library of publications, search services to help locate titles, job listings, and several other kinds of assistance for professionals.

(See also The Economist, Dec 16, p. 78 for information on electronic academic publication.)

This kind of publication is gaining popularity for several reasons. Cutting out the traditional publisher intermediary not only dramatically speeds up the rate at which new ideas get into "print", it also cuts publication costs, and provides a direct link to readers who can access the papers from anywhere on the Internet, as soon as they are available. The audience, in turn, is often encouraged to be publishers in return, using email to send feedback and reviews on articles directly back to authors. Finally, problems of calibrating production runs, unsold inventory, or unsatisfied consumer demand simply do not arise with digital networked publication. No longer do students and faculty need to wait for other scholars to return copies of popular books: they simply print their own copies "on demand".

Digital libraries: new media, new services, new institutions

If libraries existed only to store copies of books and other physical artifacts, and to share them with members of nearby communities, then these examples might suggest that such institutions are in danger of extinction. Not surprisingly, traditional libraries are not ready to give up the ghost just yet. Along with publishers, whose traditional roles are similarly threatened, libraries are attempting to redefine their functions in ways that maintain roles for them in the delivery of information in digital networked environments.

New digital libraries can try to go beyond being simply "paperless" versions of traditional ones in at least three ways. First, freed of the need to store copies of (sometimes rare) documents, they can focus more on services that will help students and faculty find and organize information in vast "virtual collections". Second, freed of the need to maintain collections in locations physically near their communities of readers, they can plan to aggregate virtual holdings into more encompassing, complete, and up-to-date collections. And third, freed of the dominance of static print (audio, and video can be digitized as readily as typed text), digital libraries can grapple with the complexities of representing and cataloging new multimedia documents.

A number of projects are engaged the important, but painfully slow, translation of paper products into digital form. Project Gutenberg (http://jg.cso.uiuc.edu/PG/), for example, aims to have 10,000 texts on-line by 2001; with a growing network of volunteers, they are now downloading about eight new titles per month. The project's mission is to provide universal access to texts. For this reason it is digitizing only public domain materials, and it is using the most basic storage format: "plain vanilla ASCII". Already today, then, a student using virtually any computer coupled to the Internet can read the complete works of Shakespeare. The National Digital Library (http://lcweb.loc.gov/homepage/new.html), part of the Library of Congress, has used its heftier resources to digitize several hundred thousand Library holdings. Not limited to simple text, these range from documents of the Continental Congress, to turn-of-the-century films to Matthew Brady's Civil War photographs. Many students and scholars are even now making serious use of the Library's historical collections, reference materials, and search tools.

Tools to find and organize information. As impressive as these conversion efforts are, though, even a quick scan of the burgeoning literature on digital libraries shows that most of the action is elsewhere. Few of the universities funded through the Digital Libraries Initiative (sponsored jointly by NSF, ARPA, and NASA), for instance, have yet to build or acquire substantial electronic holdings. Rather, they are developing tools and software agents with which digital libraries can be constructed, and effectively searched by students, faculty, and researchers (See Figure 15).

Figure 15

Providing Services to Search, Filter, and Manage Information in Digital Libraries

(This is excepted directly from the University of Michigan's Digital Library Project overview homepage http://http2.sils.umich.edu/UMDL/overview.html)

About Our Project

Partners:

The University of Michigan Digital Library Project (NSF-UMDL) is a multidisciplinary collaboration among faculty and staff throughout the University of Michigan. Initial use and evaluation of the NSF-UMDL will take place in science classes in Ann Arbor, Michigan high schools and the Stuyvesant High School in New York City, as well as instruction and research at the University. Access will also be available through Ann Arbor and New York City public libraries. External partners to the project include: IBM, Elsevier Science, Apple Computer, Bellcore, UMI International, McGraw-Hill, Encyclopaedia Britannica Educational Corporation, and Kodak.

Subject matter/content:

The content will emphasize a diverse collection, focused on earth and space sciences, which can satisfy the needs of many different types of users. The content will be supplied by publishers, although the project will eventually allow all users to publish their work. A related project, the Journal Storage Project (JSTOR), will digitize and make available all issues from the first publication through 1990 of ten economics journals to the NSF-UMDL.

Testbed description:

The UMDL will consider a complex array of technical and socioeconomic issues and will focus the research through the design, construction, and evaluation by real users of a testbed system. The testbed will consist of a cooperating set of three types of software agents: user interface agents, mediation agents, and collection agents.

User interface agents will conduct interviews with users to establish their needs such as what they need to know, and the breadth and depth of the information they require. The interface agent will also enable the user to specify areas of interest so that the system can notify the user of items of potential relevance.

Mediation agents will coordinate searches of many distinct but networked collections by taking orders from the interface agents. This will allow the user to search many libraries simultaneously in ways that meet time, relevancy, and economic constraints. The mediation agents will depend upon a conspectus that describes the contents of the various collections on the network.

Collection interface agents are associated with each specific collection and can handle searching within specific collections of text, images, graphics, audio and video. Information held in the collections may be owned by various entities, some of which may demand some control over dissemination of contents or compensation for access to their copyrighted material. The system design will provide mechanisms to protect information access and support remuneration operations.

The users of the digital library testbed will include expert researchers, students, and the general public. The library will include media types ranging from page images to interactive, compound documents and eventually real-time interaction with data. Critical to the exploitation of these resources will be ongoing programs of evaluation, training, user assistance, and outreach.

To anyone who has browsed the WWW – which itself can be viewed as a vast and unorganized digital library – the need for these search and management tools is obvious. Most of the information available on the Internet today is of questionable quality, at best. As holdings merge together, it will get tougher and tougher to find high quality products, let alone ones relevant to a chosen topic. Even more problematic, traditional tools for managing this search probably will not help much in new digital libraries. Quite aside from the fact that traditional schemes barely work even today (card catalogues and huge cross-referencing tomes almost always seem to need the hands of experienced librarians), these print indexing tools simply do not scale up well to multimedia documents that include several varieties of visual and auditory materials, as well as text. The hope is that a new generation of digital library tools and software agents will be able to understand multimedia documents, and that they will be as easy to use as they are powerful. Some of these tools are little more than "user friendly search engines" that find titles based on keyword searches. But others might fulfill, in electronic form, many of the roles of a personalized library assistant, or on-line note-taker (see Figure 15).

Aggregating single libraries into mega-libraries. Another way libraries are trying to grow beyond their paper counterparts is simply to merge holdings. Such aggregation rarely happens with traditional libraries. One-of-a-kind documents are closely guarded and highly limited resources that curators are naturally reluctant to part with; the cost of moving, recataloguing, and repositioning artifacts usually is prohibitively high; and merging libraries into a centralized location threatens to reduce access to materials by many readers in the affected communities. Access to materials in digital libraries, on the other hand, is independent of distance, so merging can only add to the resources available to communities. Moreover, merging digital holdings is comparatively trivial. Sometimes libraries can be merged just by adding a few well-placed menu items. Smart search tools can overcome many of the bumps that arise from slapping digital databases together so inattentively (for example, duplicate "hits" can be automatically eliminated before search results are presented to the student). And, if mergers are planned a little more carefully at the outset (also often aided by digital merging and interface-building tools), users can be presented an interface with the "look and feel" of a single digital "mega-library" rather than a collection of smaller ones, each with a different interaction protocol.

Today, even the largest digital libraries are small: while the Library of Congress houses over 100 million of artifacts, its on-line counterpart, the National Digital Library, "houses" a few hundred thousand, at most. When digital libraries finally acquire substantial holdings, though, they promise to address several important goals and problems of higher education. For one thing, costs could drop substantially. From a technical perspective, a document need cost no more than the price of producing it on a nearby high-quality laser printer; this would easily undercut the price of common university texts, not to mention rare volumes. Of course, publishers are unlikely to tolerate such indiscriminate copying of their property – at least as copyright law now stands. However, by aggregating their acquisitions, digital college libraries are already discovering they can use their coordinated buying power to negotiate much more effective licensing deals than publishers are willing to offer on books (see Figure 16).

Figure 16.

Bigger is better?

LIBRARIANS, UNITE -- FOR BUYING POWER

College librarians are banding together to purchase electronic resources for their institutions. "We've found that this sort of group purchasing power has really enabled us to leverage the dollars that we have and to get resources we couldn't have otherwise," says an associate librarian at the University of Texas at Austin, which buys publications through the TexShare consortium. The group buying arrangement is also advantageous for publishers, who don't need to spend as much on marketing: "As a group, we'll pay the vendor more money than they can realistically get by slogging it out school by school," says the executive director of OhioLINK, which includes more than 40 colleges and universities. The president of Britannica Online figures that more than half of the 293 institutions using his product are doing so under consortium-based licenses. (Chronicle of Higher Education 9 Feb 96 A21)

Digital libraries can improve access to educational material even as they reduce access cost. As such, they promise to be a key ingredient in future distance learning curricula. Students within a university will enjoy better access to digital materials, in part because they will be able to use them at any place and any time, not just in library study halls; and they will not have to wait for days or weeks until popular titles are returned to the shelf. More interestingly, as digital libraries merge, students can access the very best materials regardless of their institutional affiliation. Even if such mergers do not happened officially, students may be able to implement them informally. Today, for example, nothing prevents University of Michigan students on the Web from accessing digital holdings at Stanford, MIT, Illinois, or any of the other dozens of on-line libraries. For that matter, nothing prevents any Internet user – say, an unemployed worker in Detroit, or a teenager in Harlem – from perusing these digital documents.

This may not be true for long, however. It is quite easy for universities to put up "firewalls" that permit access only to their students and faculty. Technically easy, yes, but perhaps hard to justify: digital library resources, unlike books, are simply not consumed when used. With well-designed library servers and ample bandwidth, the hundreds of "authorized" users of a digital library should not notice a thousand or more unofficial ones. All this would seem to suggest that the best of world of all would be one with a single digital library, located at a single site (or perhaps distributed throughout cyberspace – what difference does it make?), and surrounded by a collection of smart, user-friendly, library tools and software agents to help find digital resources, piece them together into new documents, and share them among students and faculty. If bigger is better, why stop at merging just a few digital collections?

Challenges to building productive digital libraries. For several reasons, this vision of the future is a long way off, even if it is a good one. To begin, different universities and different communities simply may want to retain different digital documents; local decency laws, as well as informal cultural preferences, will continue to encourage diversity, and sometimes insularity, in digital holdings. Even discounting regional preferences, however, some important technical hurdles still need to be overcome. A completely universal digital library presupposes standards for representing the different kinds of multimedia information that comprise digital documents. The de facto standards for WWW homepages are a good first step in this direction, but they are a long way from complete. It is also important to remember that virtually none of the artifacts now in traditional libraries – so called "legacy" materials – have be digitized; they must be included in any digital library that even pretends to supplant a paper-based one.

However, though the technical problems are substantial, perhaps the biggest obstacles to digital libraries are legal and institutional. Higher education institutions have a long history of independence in the way they provide services. Even if economic and social arguments point towards merging digital libraries, then, it is not clear how enthusiastically universities will embrace changes that might threaten their institutional identity – especially if they can convince themselves that sharing their knowledge-base will lose students, and so revenue, to competing schools.

Finally, copyright problems could kill the development of digital libraries in their infancy. Over decades copyright law has forged a delicate balance between the interests of publishers and consumers, with libraries in the middle. "First sale" doctrine permits libraries to lend books without requiring them, or readers, to further compensate publishers and authors. Similarly, over time, libraries have negotiated extensions of "fair use" laws that allow students and faculty to (photo)copy materials without violating copyright. Current copyright law is not particularly generous to consumers, and a direct application of it to digital documents, if possible at all, would certainly not give readers the more or less free and unlimited copying privileges that are tacitly assumed in the scenarios we just sketched. But even these rules would be preferable to some of the revisions of copyright now being sketched with digital materials in mind. The 1994 "Green Paper" put out by the Clinton administration's Intellectual Property Working Group, for example, would require readers to pay-by-use. Each time a copyrighted digital document was copied, publishers would be compensated – including (the publishers hope) copies cached on a local machine whenever a document is browsed on the Web. If these kinds of changes are enacted, then, students and faculty would be required to pay each time they skimmed virtual shelves that hold recent issues of digital periodicals. Far from looking like progress, this future could be a big step backward in public access to knowledge: how many university libraries charge admission to their reading room? Cyberspace-savvy academics fear, with good reason, that digital libraries will never thrive if copyright law is rewritten to be balanced so heavily in favor of publishers (see Figure 17).

Figure 17.

Higher Education's Fight with New Electronic Copyright Laws

HIGHER ED GROUPS EYE ELECTRONIC COPYRIGHT BILL

Representatives from higher education associations testified last week before a House subcommittee, urging lawmakers not to pass new electronic copyright rules before their impact on colleges and universities can be assessed. At issue is a revised definition of "fair use" of copyrighted digital materials that threatens to eliminate or severely restrict online interlibrary loans, and would also prevent professors from using such materials as part of their courses. (Chronicle of Higher Education 16 Feb 96 A26)

Digital publishers: jumping into the future or holding on to the past?

Publishers, of course, see the threats very differently. To them, the Internet calls up their ultimate nightmare. Imagine this: the US Library of Congress buys one copy of a digital text for its collection, makes the copy available on interlibrary loan to any other library or patron (just as libraries generally do today), whereupon, since bits are so easily reproduced, every reader can manufacture his own copy with a few mouse clicks. In this scenario, the first sale of a digital book might well be the last. While admittedly fanciful, this extreme example holds more than a grain of truth. Copyright law can afford to be more generous when built-in barriers – the machinery needed to reproduce tapes, the time and cost of xeroxing paper, for instance – provide natural disincentives to duplication. But these are largely gone with digital products. So today most publishers spend as much time defending themselves against the Internet as they do creating products for it (see Figure 19).

Figure 19.

Who Wins: Publishers, Readers, Both, or Neither?

BOOK PUBLISHERS WORRY OVER THREAT OF INTERNET

Publishers may not be feeling panic, but they are clearly edgy about the prospects of new technology, which many consider as potentially significant as Guttenberg's development of moveable type.

Their chief concern is the improvement of computer technology that will make it easier and faster to scan books.

In statements to the House Subcommittee on Courts and Intellectual Property Rights, the Association of American Publishers fretted about a new world: "although not wanting to be melodramatic, publishers do fear for their future, and the well-being of their authors, when looking at a world with low-cost, east-to-use ubiquitous scanners, copiers and binders."

The publishers group commissioned several studies on the issue, including one that concluded that there is no practical way to "unilaterally prevent" unauthorized distribution of books.

Instead the association is pressing for methods to detect copyright violations with a "uniform file identifier system."

It is essentially a license plate on copyrighted work that contains the publisher's name and the identity of the person who purchased the work. The publishing industry is backing legislation before the House and Senate to make it a criminal and civil offense to alter these cyber license plates. Even they are not quite sure what form the identifying codes will take, but they do know they want them.

(New York Times on the Web, CyberTimes, March 18, 1996.)

Over the past few years, this fear slowly has started to transform through a variety of other emotions and actions: uncertain acceptance (Figure 20, panel 1), careful study (Figure 20, panel 2), strategic mergers (Figure 20, panel 3) and also hasty exits (Figure 20, panel 4). Still, recognizing a booming educational software market whose retail sales may have climbed as much as 50% last year (to over $500M), traditional publishing houses, together with some fresh competitors are beginning to sell armloads of new products in higher education.

Figure 20.

Traditional Publishers and the Digital Enemy: Fight or Flight?

PUBLISHERS WARILY EYE THE NET

Members of the Association of American Publishers have decided that they must become actively involved in the deployment of online information distribution systems, or get left behind in the dust. Up until now, worries over rampant unauthorized dissemination have resulted in "significant hesitation about investing" in electronic publishing, says the chairman of the AAP's Enabling Technologies Committee. Now, they've decided to try to resolve copyright issues "before copyright infringement on the network becomes very widespread and assumed to be the way the network works. It's a recognition that whereas in the past, publishing members of the AAP have been able to leave technological concerns to suppliers – such as compositors, typesetters and printers – in networkpublishing we cannot leave it to others."

(Chronicle of Higher Education 6/23/95 A18)

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COLLEGE TEXTBOOKS--PAST HISTORY?

Publishing CEOs to Address the Future of College Textbooks at ConTEXT '96. With the increasing presence of distance learning programs, custom-made course packs, and multimedia tools in higher education, the future form of learning materials remains a big question. To address some of these issues, chief executives from three publishing companies will share their insights and ideas on the future direction of the textbook publishing industry during ConTEXT '96: A Conference on Textbooks and Technology.

(EDUCOM UPDATE, 15 January 1996)

LEARNING COMPANY PREFERS BRODERBUND TO SOFTKEY

The Learning Company has accepted a new merger offer from Broderbund, rejecting a rival offer from Softkey, the Cambridge, Mass.-based company that has little regard for the Learning Company's management. A top Broderbund executive says, "We believe that the management of the Learning Company is one of its key assets. We're looking at a merger with a successful company that is doing a lot of things right. The last thing we want to do is alter that chemistry."

(New York Times 9 Nov 95 C3)

MURDOCH SELLS EDUCATIONAL PUBLISHING GROUP

Rupert Murdoch's News Corporation is selling HarperCollins Publishing to the U.K.-based media conglomerate Pearson PLC. A Smith Barney analyst says that "Educational publishing doesn't fit News Corp.'s image as a global distributor of information. Rupert has a lot of different objectives, and this is not one of them." Pearson PLC will now rank fourth in educational book publishing, behind McGraw Hill, Macmillan, and Harcourt-Brace.

(New York Times 10 Feb 95 p19)

Conservatism, however, still seems the order of the day, in at least two senses. First, the initial reaction of many large publishers has been to simply follow the lead of the pioneering academics who, as we mentioned, are abandoning paper journals in favor of "just in time" electronic versions (see Figure 21). One way has been to follow the strategy of buying them, if you cannot beat them: some small and informal online publishing sites are being acquired by professional publishers. BioMedNet (see Figure 14), for example, initially the brain-child of a few researchers, was taken over by Current Science, a small, but fast-moving new publishing firm that specializes in value-added electronic products. Second, while publishers certainly will develop more and better digital products for higher education – BioMedNet has grown from a single digital journal to a rich on-line community, for example – the processes by which these new titles are created in the future probably will not look much different than they do now. If you want to find places where information technology is changing the ways learning materials are created in a big way, you have to look at a much smaller scale: at the individual publisher.

Figure 21.

Paper Publishing Elephants following Digital Mice?

MCGRAW-HILL PLANS ELECTRONIC ACADEMIC PUBLISHING

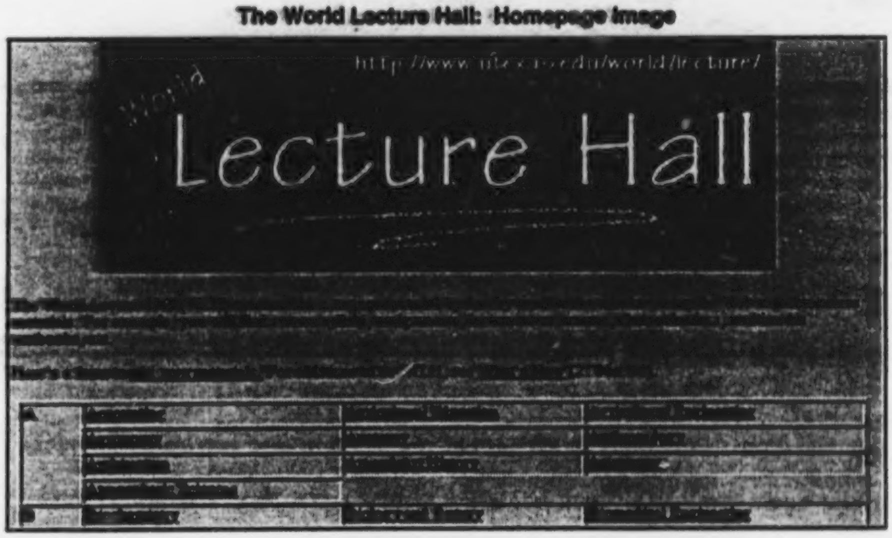
McGraw-Hill, the publishing and information services company, is considering the development of electronic academic journals that could be published more quickly and economically than traditional academic journals. An enthusiast about information technology, McGraw-Hill chairman Joseph Dionne says: "If you take this technology, you have someone submit his research, have it reviewed by knowledgeable people, the process could be done in a week or two weeks." He says he has approached such groups as the Society of Physics and the Society of Chemistry, and "there is a very real possibility that it is going to happen over the next five years."

(Financial Times 16 Oct 95 p19)

Internet impact: Innovative ways to create new instruction and learning materials

Consider again the World Lecture Hall, a virtual repository of on-line course materials. We have discussed how specific courses here might be part of a new generation of distance learning class materials. But, now look at the Hall itself, rather than its constituent products (See Figure 22). Its most prominent feature is a large table that organizes specific courseware by subject matter; this is much like standard university course catalogue – except that offerings are full sets of course materials, rather than brief course descriptions. The Hall also provides tools that allow new courses to be easily added, and a means of identifying new entries (a very valuable resource for frequent browsers, since hundreds of courses are already resident at the Hall).

Figure 22.
The World Lecture Hall: Homepage Image



The World Lecture Hall is a Web site managed out of the University of Texas. Its main feature is a large table that organizes several hundred courses, alphabetically, by subject name. Users select a subject link which then leads to a page listing all specific courses of that type. These course links, in turn, can be followed down to their component pieces: lecture notes, tests, and so on.

The World Lecture Hall encourages new course submissions, which may be completely original or modifications of ones already resident. However, as of 4/96, it provides relatively few tools for users or developers beyond a "What's New" link that lists recent additions, and the table of course offerings itself. The Hall's developers apparently do now review courses offered by developers, follow other policies for quality control, or provide tools to help consumers find and compare products.

The World Lecture Hall demonstrates two very powerful benefits of information technology for education; one already widely touted, but the other less so. Relatively familiar is the idea that new technologies encourage individual "home grown" production. In higher education, we have seen this in electronic journals that bypass traditional publication bottlenecks, as well as in on-line courses constructed by individual faculty virtually from scratch using digital materials. Outside education, the examples are often even more compelling. Today, for example, audio and video desktop publishing puts at one's fingertips the facilities that just a few years ago were available only to large, well-funded professional studios. Using these tools, small "grass-roots" print-journalists, movie-makers and record-producers are already making significant inroads into markets traditionally dominated by big players. There is no reason to believe that educational publication and the creation of instructional materials will be immune from these sea changes – at least on technical grounds.

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The second feature has more to do with the World Lecture Hall itself than the nature and origins of its constituent on-line courses. The Hall attempts to provide a location and supporting tools that would encourage faculty not only to create new on-line course materials, but to share them with others. Because the Hall is implemented as a Web homepage, all materials from a course can be down-loaded, trivially, from the Hall site (which happens to be in Texas, at least today) to the browser's home machine. Using simple but very powerful digital cut-and-paste tools, this copy can be edited into a new course, possibly one for a slightly different topic and audience. Perhaps this will also be a better product. In any case, the new version can be returned to the World Lecture Hall, adding again to the materials available to share with the academic community. Eventually, this kind of "chaotic cooperation" might lead to a vast collection of digital courses of progressively better and better quality, as a new set of course creators "stand on the shoulders" of the current crop.

Challenges to building productive individual publishing communities in higher education. How likely is this rosy future? On the one hand, early indications seem promising. It was quite possible when the World Lecture Hall was established (in 1994) that no one would have come to play in their site – after all, at the beginning the Hall contained very few on-line courses, and so had little value to browsers. But, by February 1996 the Hall contained several hundred courses; and, according to its managers, dozens of offerings flow in each month, at increasing pace. In short, at least this communal repository of digital instructional material demonstrates what economists refer to as positive "network externalities": the more users adopt the product, the more valuable (but not more scarce) it becomes for other users.

On the other hand, most home-grown products, whether in the form of videotapes, audio recordings, or Web homepages, suffer from a common problem: their creators see them as priceless, but few others may. Just as once we were bored to tears by our neighbors' home slide shows, today most Web surfers are frustrated by the thousands (now probably millions) of homepages that serve only to hide the few gems they seek. In the case of virtual collections like the World Lecture Hall, it is likely that if potential consumers (who may also be producers) cannot find quality digital course materials, they will cease browsing this site (and adding to it). If so, the number of new entries will decrease, and, with fewer shoulders to stand on, the overall quality of offerings is unlikely to improve quickly, if at all. In this future, far from flourishing, the World Lecture Hall would likely disappear within a few semesters.

Whether or not such sites foster a productive community of grass-roots publishing in higher education will depend on a number of factors. Luck and good timing may play a role; if homespun sites develop strong early products, for example, they may attract the attention and new contributors needed to sustain them through their formative period. Another factor has to do with the ease of finding quality products, even if they exist. Internet search engines and smart agents already help consumers locate useful sites and ignore irrelevant ones. Providers also have several means at their disposal to simplify search and improve product quality. Passive tools, such as the World Lecture Hall's table organization and "What's New" option, help make navigation easier for consumers. Other providers (though not the World Lecture Hall) take more active steps, preferring to control the quality of products they include in their collections, rather than just relying on consumers to cut through irrelevant materials with search tools. One ingeniously simple idea that "virtual yellow pages" (e.g., see BigBook, http://www.bigbook.com) are trying is to let users rate any business in their database and permit new buyers to see these reviews – in the long run relying on consumer popularity to organize products and shape the market. Though this strategy has not been applied to educational courseware databases, the implementation would probably be very simple; however, the long-term consequences of using such a quality management scheme would certainly be far from easy to predict.

Taking a more traditional approach, electronic journals like BioMedNet have instituted formal peer review procedures. Similarly, many of the electronic discussion groups on Usenet (the newsgroup side of the Internet) are moderated, rather than uncontrolled. Moderators can play a wide range of roles, reorganizing and packaging submitted materials, editing copy, adding editorial comments, and even censoring contributions outright. All this sounds very much like the value-added functions of traditional publishers. It hardly comes as a surprise, therefore, that publishing firms, seeking to redefine their roles in the digital age, are now looking to form partnerships with developers of home-grown online course materials for higher education. In addition to ensuring quality and packaging new products, many publishers are planning also to market the courseware, secure copyright agreements, and arrange licensing (see Figure 23).

Figure 23.

Grass roots developers and traditional publishers: A marriage?

UNIVERSITY ONLINE

University Online, a small Internet publisher that licenses 200 ready-made high school and college courses, is working with George Washington and George Mason Universities to create tutorials and more online courses at the higher education level, and is seeking more universities for similar alliances. The company's president is working with textbook publishers to obtain the electronic rights to their materials, and will then pay the publishers' royalties and split the tuition with the universities that license its products.

(Wall Street Journal 24 Feb 96 B5D)

Individual publishing on the Internet is so new that it is difficult to determine how significantly it will contribute to the creation of new instruction and learning materials. If it flourishes, however, this innovative approach could speak to several important goals and problems of higher education. Home-grown publishing is now technically feasible because information technologies greatly simplify constructing, editing, and sharing of documents. This many invite the creation of many low-quality products; but, suitably channeled, high-volume and high-speed production also has its good side. Obviously, the easier it is for individual faculty to create courseware (or to tailor existing materials into new packages), the more they will be able to offer diverse materials to an expanding and increasingly divergent student population. Responding to a nearly overwhelming need for remedial instruction, for example, faculty from the Cal State system might be able to put together a fresh physics curriculum in short order by combining some of the simpler digital simulations, assignments, and exams from any of the over 25 physics courses now on-line in the World Lecture Hall.

This same flexibility could permit institutions to build new courseware and learning products that respond to the rapidly changing demands of industry. Assuming popular predictions are right, this will not just be a one-time effort to bring educational services into line with business needs. Robert Reich, among others, says workers will need to retool for up to 5 job-changes per career. If so, rapid changes in instructional materials will be the rule for the foreseeable future; and the versatility that new information technologies bring to educational production will be critical in meeting these demands. In short, just as information technology already helps manufacturing and services industries dramatically shorten production cycles, it could allow higher education to meet the demand for "just in time" or "on demand" learning, as it has already help solve the problem of just in time academic publishing.

Reflection: Many interesting options, many hard choices – a reprise

Viewed broadly, the ways that information technologies might change how instruction and learning materials are created have much in common with they ways they could alter how instruction and learning are delivered. In both cases information technologies, cleverly used, could provide many different kinds of applications, not just one or a few. In both cases, the applications could speak to a variety of goals and problems in higher education, helping to reduce costs, enrich and diversify course offerings, expand access, and increase responsiveness to industry demands and social needs. And, in both cases, some of the most valuable uses of information technology may not simply improve educational productivity, but rather will require institutions to consider moderate or extensive structural transformations.

By digitizing library holdings, for example, universities can expect save space, reduce acquisition costs, seemlessly combine multimedia documents with traditional text, and provide students and faculty with a new generation tools for finding information and organizing it into intellectual products. But, though a single university can benefit from digitization, cross-institutional cooperation may be critical if digital libraries are to make the best-quality materials available to students and to reach the broadest audience. As we have noted, copyright problems will challenge this kind of library merging; however, it is also clear that barriers between higher education institutions also may slow such a transformation. By the same token, smaller grass-roots publishers on the Web, rather than larger traditional publishing firms, look to be nimbler providers of new digital courseware that will meet changing industry needs. But, at least today, the individual publication process is chaotic, to say the least. In the World Lecture Hall, for instance, faculty often cut-and-paste new curricula from previous offering, with little concern for copyright or institutional origin. This kind of highly informal cross-institutional collaboration has been common in academic research. Nevertheless, in the past most higher education institutions have been much more reluctant to share their course offerings, informally or otherwise. So, like digital libraries, individual academic publishing may stress or even transform existing institutional structures, rather than simply enabling them to operate more productively without fundamental change.

A slightly different way to view all this is that the Internet is beginning to foster new academic and learning communities across the Web. Most of these communities are organizing along functional lines – developing courseware, conducting research, sharing curricula, for instance. Common interests and expertise are much more important in defining these communities than distance, a factor that cheap high-bandwidth connectivity largely erases. For similar reasons, most cyberspace communities tend to ignore institutional boundaries where they conflict with emerging functional interests. These forces are beginning to give rise to new communities of practice that, at the very least, criss-cross previous structures, and, more extremely, can erode old higher education structures while building new ones.

Creating Connected Educational Communities

Earlier sections considered how information technologies can contribute to several well-defined higher education missions (delivering and creating instruction), and in doing so could address some major problems that higher education now faces. But the last section discussed how the Internet, in particular, might play a much broader role: fostering *electronic learning communities*. Not surprisingly, the potential effects of these communities on specific educational problems are much tougher to gauge than those of more well-defined technologies, such as distance learning. For one thing, these communities are often emerging spontaneously, rather than as part of a deliberate plan aimed at specific educational goals. Moreover, since Web-based groups are so new, it will be some time before the dust settles and we see which key problems in higher education they might help solve, if any. And, if on-line communities do help improve educational outcomes, almost certainly they will do so not simply by reducing labor costs and increasing the productivity of traditional higher education delivery systems, but by transforming learning and teaching practices.

In spite of these uncertainties, however, these new communities are worthy of attention: if they realize even a fraction of the benefits BioMedNet or the World Lecture Hall seem to promise, they will make a substantial mark on higher education indeed. In this section, then, we will briefly present a few such emerging communities, noting how they might address key educational problems, but also keeping in mind how tentative these possibilities are, at least today.

If you scan the WWW for on-line educational communities, it quickly becomes apparent that, however formative, they are also ubiquitous. We have reviewed communities that conduct and publish research, and share curricula; but others are appearing to fulfill almost every information-based function associated with higher education institutions – both within and across traditional organizational boundaries. Within institutions, for example, governance and administration issues are being discussed not just through academic committee meetings, but also using various network technologies, including email, more organized electronic discussion groups, real-time chat rooms, and Web pages (see Figure 24). Just as in other businesses, here information technologies may cut out layers of middle-management, and give faculty more direct input into institutional decision-making. This use of information technology to "flatten" organizational structure is hardly novel in business, but it is still rare in universities, where decision-making structure is still largely that of the cloisters.

Figure 24.

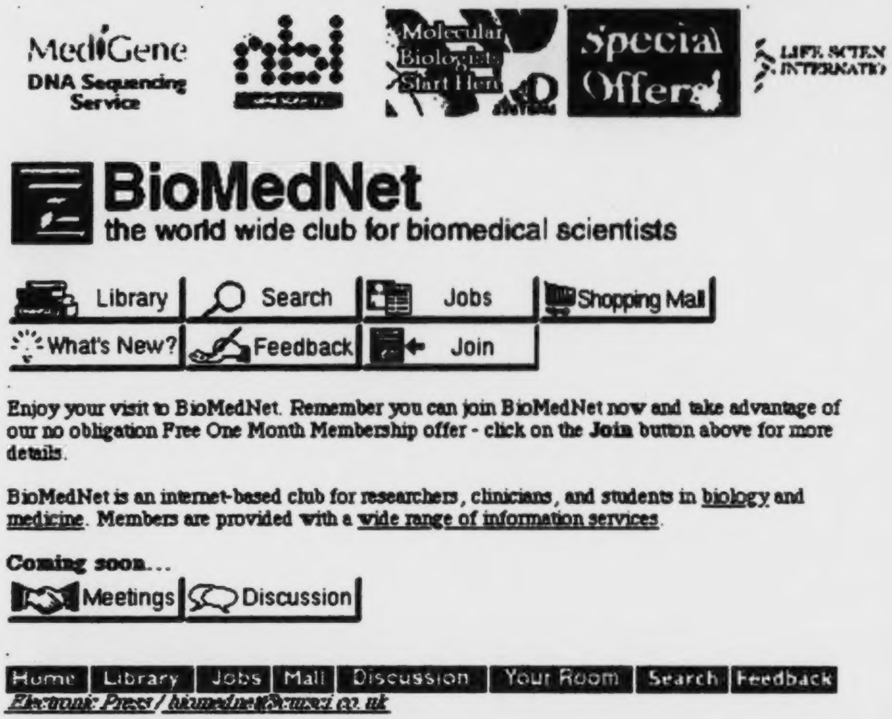
Academic Technology Planning using Information Technologies.

The University of California, Davis is using Web pages to help create a new Information Technology Strategic Plan (see url http://www.ucdavis.edu/IT/). The root page includes links to current versions of parts of the strategic plan, service guides and reference materials, University technology reports, as well as links that route browsers to any of UCD's current Information Technology Operating Units (e.g., The Center for Advanced Information Technology). All this, and more, acts as background material for faculty and Information Technology Strategic Planning Committee members who can contribute to the on-going planning and design process. Some of the planning was conducted in focus groups and face-to-face community meets. But later deliberations were conducted using on-line forums.

Internet applications such as these might help improve the flow of information within higher education institutions and help speed up internal decision-making. Perhaps the most interesting feature of most successful on-line communities, however, is that they often start small, with a single purpose like administration in mind, and then expand – not only attracting a larger collection of participants, but also adding functions. Look, for instance, at some of the virtual communities that been around the longest – those in academic publishing. BioMedNet, as we mentioned (see Figure 14), began its virtual life as a single electronic academic journal in 1991. Today, bolstered by the Web, which permits a richer collection of materials to be placed on-line (the early electronic journals relied mainly on text, and email-like communication protocols), and an infusion of capital, BioMedNet has expanded its functionality to include an on-line library of publications, a shopping mall, a collection of collaboration tools, and even an electronic bulletin board of job opportunities (see Figure 25). Virtual discussion groups and on-line conferences are the most recent additions to this growing community.

Figure 25.

From on-line journal to on-line community: the metamorphosis of BioMedNet.



Enjoy your visit to BioMedNet. Remember you can join BioMedNet now and take advantage of our no obligation Free One Month Membership offer - click on the **Join** button above for more details.

BioMedNet is an internet-based club for researchers, clinicians, and students in biology and medicine. Members are provided with a wide range of information services.

Coming soon...

Electronic Press / [illegible]

(The following comes directly from the BioMedNet homepages.)

Membership of BioMedNet gives you:

1. Free access to the search and browse functions in the library. To access the full content of publications in the library, you will have to purchase subscription giving you an unrestricted access for a period (usually a year) or purchase an access to individual items (such as papers, parts of books, entries in databases) at prices determined by the publishers of these publications. You will be able to use your BioMedNet account for these purchases.

2. Free access to the search, browse and contact functions of the Job Exchange and free placing of Job wanted entries.

3. Free use of the search and contact functions of the Shopping Mall. You will be able to purchase items in the shopping mall (books, CD-ROM's, subscriptions to print versions of periodicals. software, lab equipment, chemicals etc.) using your BioMedNet account.

4. Free use of the range of collaboration and communication tools of BioMedNet, including private and public rooms, newsgroups, discussion. etc. (under construction).

5. The use of BioMedNet account system allowing secure purchasing of information, services and products with detailed reporting, use of institutional and personal accounts, and other useful functions.

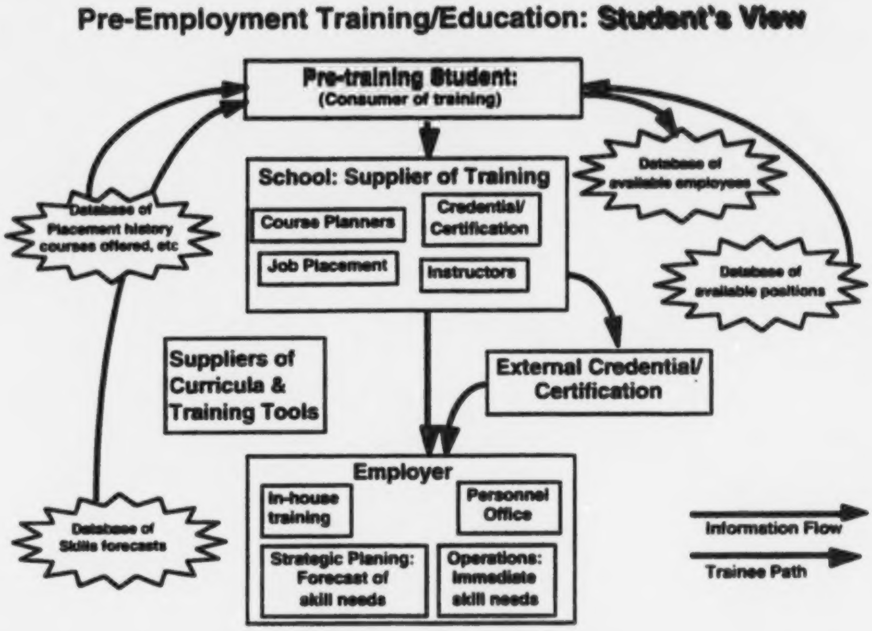
6. Benefit from a range of special offers, free news and other services available exclusively to BioMedNet members.

BioMedNet and many of its contemporaries look at once familiar and novel. The individual services they provide all have analogs in traditional academic communities: libraries permit faculty and students to take out books on loan; meeting rooms house conferences; administration offices can arrange purchases on individual or institutional accounts; and department bulletin boards post flyers that announce new academic positions. Several things, however, may make the on-line versions more powerful.

One is how the pieces and players in these on-line communities can be seemlessly combined. BioMedNet offers higher education faculty in biological and medical science almost one-stop shopping for professional needs. In a couple of hours, professors might be able to catch up on the latest journal publications, read critical reviews, discuss new research ideas with colleagues from other countries, examine new books in their field, check out job listings and place orders for these and other products. This certainly does not exhaust the on-line services these providers will soon offer (and which the growing communities will soon demand). One recent addition in BioMedNet, for instance, permits members to create their own virtual "rooms" within the community, that can contain a profile (which helps BioMedNet suggest products and people of interest), details of your credit card account (to facilitate electronic purchases), your monthly billing statements (with a complete record of past purchases), and your community email account (where you correspond only with BioMedNet members, not the Internet at large).

If designed properly, some virtual parts of electronic communities may actually do much more than their paper counterparts, not simply provide the same services more conveniently. For example, job listings do not need to be (and in some Web sites are not) limited to static announcements of required qualifications and pay ranges. Links can permit Web applicants to visit homepages of potential employers, or even take on-line tests and interviews. This can draw into a growing community a wide range of educational stakeholders who rarely talk much to one another. As the environment sketched in Figure 26 suggests, for example, information technologies already provide tools that help students learn about employment opportunities, let employers converse with candidate workers, and enable schools keep up to date about the changing needs of the job market. And, the more these networked communities extend to new players and link them in different ways, the more new communication technologies look to be redefining the educational communities, rather then just streamlining ones that already exist.

Figure 26.
A schematic of a possible information environment to support the transition to work



Pre-Employment Training/Education: Student's View

Pre-training Student:
(Consumer of training)
School: Supplier of Training
Course Planners
Credential/ Certification
Job Placement
Instructors
Database of Placement history courses offered, etc
Database of available employees
Database of available positions
Suppliers of Curricula & Training Tools
External Credential/ Certification
Employer
In-house training
Personnel Office
Strategic Planing: Forecast of skill needs
Operations: Immediate skill needs
Database of Skills forecasts
Information Flow
Trainee Path

This information environment was designed as part of a RAND transition to work study. One of the main goals of the research was to provide models for how network technologies could help increase the bandwidth and flexibility of communication between students, schools, and the workplace. Implemented as Web homepages, the prototype system connected a local vocational school, and its students, to nearby employers. As part of the work, the project also showed how several kinds of databases, describing schools, students, skills, and jobs, could be constructed to add substantial value to the network as a whole.

It is a good bet that more expansive communities, fulfilling even more innovative functions and encompassing a broader collection of stakeholders, will appear shortly. At present, however, the best – or at least the most complete – of these electronic communities seem focused on research and academic publication, rather than on other missions of higher education. This may be beginning to change, though, as some institutions start to take the idea of combining educational functions in electronic communities to its logical conclusion: the virtual university.

Virtual Universities: old wine in new bottles?

While the image of a virtual university seems the inevitable end-state of a movement to digitize higher education, many institutions have been "virtualizing" themselves, in bits and pieces, for years. Recall that the Open University, probably still the world's largest virtual campus (however this loose term is defined), has been using telecommunications to offer distance learning for over 3 decades. In the past, OU and others mainly relied on TV, radio, and telephony; today, the Internet and WWW are the vehicles of choice as universities go on-line. According to Institute for Learning Technologies at Columbia University (http://daemon.ilt.columbia.edu/ilt/) nearly 500 universities in the United States already have some "Web presence". In many cases, this still just means a homepage providing a brief description of the institution, its mission, and addresses to contact if the Internet browser wants any real information about admissions, requirements, or courses. The next steps beyond basic public relations often include virtual campus tours using interactive maps, digital campus periodicals or newspapers, homepages for specific departments, university centers and faculty, and even on-line application forms.

These sites provide prospective students with a wealth of information they can use in planning their college careers. As of winter 1996, however, only a few established public or private universities have "virtualized" core teaching and learning functions.[7] And, of those that have, most still limit on-line offerings in several ways. The University of British Columbia provides on-line courses that are mainly *about* the Internet itself, rather than other subjects; UWired (part of the University of Washington) weights its offerings towards net courses too, and also follows the strategy of overlaying networked courseware on existing courses – the on-line resources are essentially enrichment materials – rather than creating stand-alone virtual courses; and, while Arcadia University boasts an attractive set of pages at its Web site, it only offers continuing education classes at a distance (and then using video rather than the Internet).

Perhaps not surprisingly, the most complete virtual universities on the Internet are not extensions of existing institutions, but ones that have been created in cyberspace almost from scratch. Though they by no means rival their traditional counterparts in size of faculty or range of courses, on-line universities like Athena (see Figure 27) are beginning to put together digital versions of all of the familiar pieces of a campus. Founded in 1995, by April 1996 Athena already employed roughly 25 faculty (some full-time and others who teach at traditional universities) and offered courses in over a dozen subject areas. Like a typical university, Athena grants liberal arts degrees (though it is still waiting to receive accreditation from a regional accreditation body), has a transfer credit policy, and offers a detailed, and surprisingly traditional, core curriculum. Athena differs substantially from most higher education institutions only in its admission policy (because finite resources like classroom space are not an issue, enrollment is open and unlimited), and its teaching methods. Like courses in the World Lecture Hall, all Athena courses rely heavily on the Web. However, Athena courses go beyond typical WWW homepages, which are often a rich multimedia documents but rarely ones that permit the kind of intensive interaction among students and teachers that are the hallmark of good learning environments. Following others who seek to develop high-quality learning environments for the Web (see Figure 10), Athena's idea is to mix the richness of Web documents with the dialogue of "MOOs": a Multi-User, Object Oriented environment. Behind this techno-jargon is a simple idea: introduce into the WWW world of graphics, audio, and text, a communication protocol that permits students and teachers to talk with one another across the network in real-time, and to share multimedia "objects" as they chat.

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[7] This sort of statement cries out for some research. At a minimum: How many universities are actually doing important stuff (not just public relations) on the Web? What are they doing (at least a rough classification of on-line strategies)? Who are they and what are their strategies (existing institutions, virtualizing bit-by-bit, or new virtual campuses created from scratch)?. As of 4/96, we haven't found any research that answers such questions.

Figure 27.

Athena University: A Familiar Organization in a New Medium?

This is Athena's homepage (http://www.athena.edu/Athena-Home.html). From here, browsers and prospective students can link to the campus (which redirects students to telnet through which can begin to engage in MOO-based conversations), and view the course catalogue (which in turn provides links to specific course descriptions, as well as to admission requirements, registration information, degree requirements, and the core curriculum). In addition, users can quickly link to an on-line student guide and faculty directory. The student guide provides detailed instructions on how to use the on-line technology that comprises Athena's infrastructure. The faculty directory lists all current staff, provides email links to most, and homepages and vitae for many.

Athena is administered by Virtual Online University, Inc., a non-profit corporation offering a novel approach to academic excellence, professional development and life-long learning.

Athena is quite consciously an attempt to capture the best of traditional university structure in a virtual version. If it acquires its accreditation, and can keep costs low while continuing to offer courses to all comers, it will likely succeed in this goal.[8] But this is not the only approach to developing a virtual university, nor necessarily the best one. A few groups are viewing cyberspace an opportunity to rethink the structure of educational

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[8] As of Winter 1996, however, a liberal arts degree from Athena does not come cheap – roughly $12,000 (120 credit hours at $100 per hour). Costs may drop in the future however, if Athena can attract more students while requiring relatively few added faculty. But, even now, Athena clearly undercuts higher education institutions (where degrees usually cost over $25,000), and private schools (where $50,000 is rarely enough).

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institutions from the foundations up, rather than as a new tool for an existing organization.

The Globewide Network Academy (GNA, http://www.gnacademy.org) is one such experiment (see Figure 28). In a broad sense, GNA is something like a mix of Athena and the World Lecture Hall. Like Athena (and unlike the World Lecture Hall), GNA offers more than just a collection of on-line courses; it also includes virtual discussion lounges, where teachers, students, administrative and support staff and technical experts can engage in on-going electronic discussions about the academy. The student lounge also contains a collection of links that comprise an ad-hoc digital library, and another set of links to career resources. Like the World Lecture Hall (and unlike Athena), however, GNA is not developing its own courses. Rather, it encourages institutions and individuals to list with GNA existing courses for on-line distance learning, and then provides a collection of value-added and brokering services to help students find the courseware they want and to put them in contact with the providing institutions. At the same time, GNA offers support services for teachers and contributing institutions that, they hope, will improve the quantity and quality of the products GNA manages. Initial indications look promising; GNA has already catalogued thousands of courses, contributed by almost 200 sponsoring members (mostly American public universities – including Athena!).

Figure 28.

Globewide Network Academy: A Now Organization in a New Medium?

(This is directly excepted from an on-line letter by the president of GNA, July, 1995; see http://www.gnacademy.org:8001/HyperNews/get/documents/pres-letter.html)

What is the Globewide Network Academy?

The Globewide Network Academy is a federation of educational and research institutions. We exist in order to provide a central location at which students and teachers can find each other, and to provide administrative support services to aid teachers in teaching.

Much of the reason for the existence of GNA lies in the belief that the traditional departmental structure of universities is reaching the end of its usefulness and that new organizational structures are needed if universities are to provide education for the masses of the world with the diminishing resources which are available to them.

Universities today are both too large and too small. An average university is simply too large to have a coherent focus, and most universities today are indeed composed of many sub-groups many of whom have conflicting ideas of were the university should go. As a result, one has huge amounts of energy being wasted in academic politics when in becomes necessary for the university to set priorities.

At the same time universities are too small. If you go to five different universities, you generally find five different registrar departments, five different payroll departments, five different computational systems, etc. etc. This leads to tremendous and costly administrative duplication which serves absolutely no educational purpose.

At the same time, universities are facing increasing pressures from the outside. Tuitions are rising far beyond the ability of middle class family to pay, and government grants for research and education are drying up as governments face budgetary pressures. At the same time, universities are victims of their own success as the doctoral students that they are producing are unable to find any job openings in traditional academia.

The purpose behind the federation model of GNA is to deal with both of the structural problems of the traditional university so that it can deal with the challenges that face it in the opening years of the 21st century. GNA consists of independent members, each of whom has their own internal finances and course and curriculum policies. The core organization is responsible for providing computational and administrative support as well as providing a central location for students to find the courses that they are looking for.

Reflection: networked communities and higher education goals

Electronic communities now emerging on the Internet and WWW may address several key goals and problems in higher education. In the simplest cases, putting basic functions on-line will simply streamline existing communication processes, helping both to reduce costs and increase access. Enrolling through the Web, or email, already saves on paperwork and administrative time; students also avoid long lines and frustrating delays in finding courses with open spots that suit their needs. But, although valuable, these uses of information technology are certainly not new with the Internet.

New network communities now are just beginning to take advantage of more unique characteristics of the Internet and Web to fulfill a wide range of educational functions. Within higher education institutions, web-based dialogues might help open-up decision-making processes, and flatten administrative structure. If lessons from the corporate use of information technologies hold here, this might encourage universities to rethink more rapidly the products (courses) they offer, and thereby be more responsive to the needs of business. Such responsiveness might be enhanced further if the same networks that improve communication within higher education also provide direct links to the business community. Then, students will get direct access to potential employers; employers will be able to query schools for lists of promising prospective workers; and industry might have more of a say in academic course design.

As electronic communities continue to grow they should help meet more of higher education's pressing needs. But growth means more than expanding to include a larger number of students and faculty; it also means connecting together a broader set of stakeholders and encompassing additional educational functions. Such growth seems to point to virtual universities as a kind of holy grail for higher education: a single cyber-institution that provides all the functions of the academy, digitized, and tightly knit together through high bandwidth network connections. Certainly, virtual universities look like the logical conclusion of all this digital construction in the sense that it is hard to imagine any digital academy that is more inclusive in its functions. Athena and others are deliberately attempting to build cyber-institutions that include as many pieces as possible of existing universities, from student centers, to libraries, to classrooms, and faculty lounges. Some even include images of virtual ivy-covered walls. That these visions are so all-encompassing and vivid is, perhaps, the main reason that the popular press seem to view virtual universities as the most cutting-edge and ambitious of all applications of information technology to higher education.

Ambitious: yes; cutting-edge: not really. Certainly, building anything with the scope of a fully virtual university is challenging, to say the least. But, although the technology is thoroughly modern, the institutions being constructed in Athena, and planned by other developers, are actually about as traditional as can be. GNA, on the other hand, demonstrates that a virtual university might transform the structure of higher education rather than simply streamline it, or improve its productivity (in any simple sense). GNA is trying to do more than digitize the past: while it replicates some conventional functions (e.g., virtual student lounges), a few familiar functions are distributed or eliminated (e.g., databases collect courses from other higher education institutions; GNA does not create them), and still others seem quite new (e.g., GNA's brokering services to connect providers with consumers).

None of this suggests that GNA is more likely to succeed as a virtual university than Athena. Both may succeed or fail, and in any case their fates may have little to do with the underlying structures of the institutions. The comparison, does, however, illuminate two broader points. First, network-based information technologies can be used to deliver educational services in many different ways. Athena and GNA are two options, but doubtless others soon will surface that are more radical than GNA in the way they reorganize traditional higher education functions – partnering with more global institutions for digital library services, or offering education on a "per concept" basis, rather than providing whole programs of study, for instance. With equal certainty, other virtual universities will appear on the Web that are as traditional as Athena. It is in the nature of a flexible new technology like the Web that it can be as easily configured to mimic an existing institutional structure or medium (see Figure 1) as it can be crafted into a novel structure. If anything, repeating the past with new technology is easier: new designs take considerable creativity to devise, and lots of hard testing and refining to prove.

This brings up the second point. Many public and private higher educational institutions have been reluctant to experiment with more novel designs for using information technology. Not only are newer ideas tougher to devise and more expensive to implement, but digitizing old institutions may still seem like a perfectly serviceable, and much more certain, strategy. However, if current higher education institutions are not interested in conducting high-risk experiments, new external providers of educational services are more than willing to try. If they succeed, they may make holding to the status quo less and less tenable.

Competing with New External Providers of Education

Higher education institutions may be skittish about the uncertainties associated with more innovative uses of information technology to build learning communities, but a growing collection of external providers – mainly proprietary, for profit, institutions – are embracing them. A brief review of these can yield several insights for higher education: allow them to size up the competition, suggest some concrete models of technology-based reforms worth borrowing, and even offer opportunities for collaboration as well as strategies for competition. Because the literature on these new providers is very scant, we will limit ourselves to discussion of just a few examples.[9]

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[9] Surveying external providers would be a worthy research topic. Many basic questions beg answers: (i) how many of these on-line external providers are offering contract training?; (ii) how many are now shifting over to offering "serious" higher education courses?, (iii) how are growing demands for "knowledge workers" affecting the demand for these providers?; (iv) what will new business practices that rely on them look like (presumably decentralized, networked – transformed by IT itself)?. This would give

The proprietary training sector covers a wide range of schools and providers. Some grant degrees, while others offer only short courses and training seminars. Some focus on routine clerical, sales, and cosmetics skills; yet others offer professional classes in law and architecture. About the only feature all share is that fees and tuition cover costs, since none are supported directly through taxes. Because their operations are so different, it has been difficult to measure the size of this sector, compared to public and private academic institutions. Clearly, though, it is large and growing. California alone now boasts thousands of proprietary schools (compared to a couple of hundred traditional higher education institutions), bringing in an estimated $1.4B in tuition, as of 1992. This promises to expand substantially, mainly because in the future businesses, not individuals will be the primary clients. In 1994 businesses spent roughly $50B on training, and while much of this was done in-house in the past, it is increasingly being outsourced to external providers.

Probably the biggest, and certainly the fastest-expanding part of this sector belongs to companies providing training to use new information technologies. In 1995 corporations in the United States paid over $15B in information technology training, a figure that will probably grow about 15% per year to over $30B, by the end of the century. Courses here cover everything from mastering the nuances of Windows95 to acquiring much more generic skills in object-oriented programming, analysis, and design. Not surprisingly, the courses are not only about high-tech, but use high-tech: they generally come from external providers who specialize in training products that make the heaviest, and often most innovative, uses of information technology. Some, such as The Teaching Company (see Figure 11) and Learning Tree (http://www.lrntree.com/) offer thousands of computer-based training (CBT) course products, most created to meet the needs of large corporate clients. Microsoft, Intel, Novell, and other large software and hardware companies also offer a wide range of training courses – but ones that are primarily tailored to their own products, rather than to clients' interests.

Microsoft takes over. At first glance, Microsoft's On Line Institute (MOLI) resembles Athena in several ways. In some respects, it aims at one-stop shopping for training, supplying on-line enrollment, certification programs, exam preparation, as well as a list of Web-based courses (see Figure 29)[10]. But MOLI's relationship with students, course providers, and specific classes, is actually anything but traditional. More like GNA than Athena, MOLI mainly furnishes the infrastructure and value-added services that organize Web-based courses on products like Visual Basic, C++, and Word. Third-party on-line content vendors (OCVs) develop most of interactive the courseware products; and different groups, called authorized on-line classroom providers (OCPs), build specific classes from these materials, adding human learning advisors and other curriculum material as needed. Students then interact with MOLI by searching the course-list database to find OCPs whose courses meet their needs, and whose location is suitable (distance matters for subset of the courses that include extensive face-to-face interaction with learning advisors). Students also can make use of various common information resources in MOLI, such as the student union, library, advising center and bookstore.

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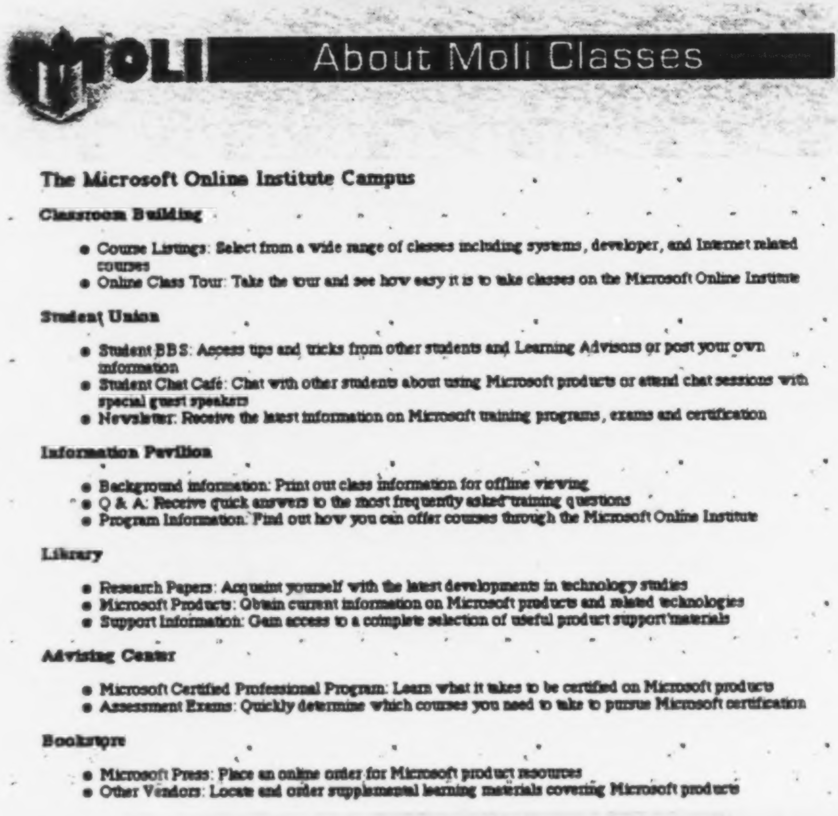
higher education a better foundation for thinking about how to train knowledge workers, and therefore how to compete with new providers that are already training them.

[10] Microsoft has a large Web presence. In addition to pages that comprise MOLI and that provide information on its products, it also provides ample educational materials, reflecting a broad investment in K12 and post-secondary education.

Figure 29.
Microsoft OnLine Institute



About Moli Classes

The Microsoft Online Institute Campus

Classroom Building

- Course Listings: Select from a wide range of classes including systems, developer, and Internet related courses
- Online Class Tour: Take the tour and see how easy it is to take classes on the Microsoft Online Institute

Student Union

- Student BBS: Access tips and tricks from other students and Learning Advisors or post your own information
- Student Chat Café: Chat with other students about using Microsoft products or attend chat sessions with special guest speakers
- Newsletter: Receive the latest information on Microsoft training programs, exams and certification

Information Pavilion

- Background information: Print out class information for offline viewing
- Q & A: Receive quick answers to the most frequently asked training questions
- Program Information: Find out how you can offer courses through the Microsoft Online Institute

Library

- Research Papers: Acquaint yourself with the latest developments in technology studies
- Microsoft Products: Obtain current information on Microsoft products and related technologies
- Support Information: Gain access to a complete selection of useful product support materials

Advising Center

- Microsoft Certified Professional Program: Learn what it takes to be certified on Microsoft products
- Assessment Exams: Quickly determine which courses you need to take to pursue Microsoft certification

Bookstore

- Microsoft Press: Place an online order for Microsoft product resources
- Other Vendors: Locate and order supplemental learning materials covering Microsoft products

Just as it provides various tools to help consumers, MOLI also attends very carefully to its suppliers. In contrast to the World Lecture Hall, which seems to accept all course offerings it receives, MOLI constrains course providers in at least three ways. First, the Institute defines the topics (the Microsoft products and programming skills) for which it will accept courseware; second, it evaluates courseware and classes, and admits only OCVs and OCPs that it authorizes; and third, it imposes standards for courseware development that help ensure Web-based content developed by different OCVs will run on a wide range of platforms and will work well when put together into larger course products. MOLI encourages content vendors and course providers to meet these demands by offering tools and infrastructure, including the bookstore and library, that help create high-quality products. But the primary incentive is financial: OCVs can sell

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curricula to OCPs and to other interested (but not authorized) parties through the MOLI bookstore; OCPs sell courseware directly to individual students or corporate clients.

This model for instruction delivery has many interesting features, some also shared by communities like Athena and GNA, but others that look quite new. Because MOLI has no physical infrastructure and few labor expenses, the cost of courses is low (its not clear that Microsoft makes a penny from MOLI, since its main goal is to sell software, not training). In spite of this, and in spite of the fact that Microsoft creates little courseware itself, by carefully managing its third-part vendors, MOLI effectively can provide "just in time" training services; vendors move rapidly to create courses for new Microsoft products, to reach the market ahead of their many competitors. Also, like Athena and GNA, Microsoft is very concerned with assessment exams and certification of students. However, in contrast to other virtual universities, MOLI has no concept of admission or course-load; students simply purchase instruction as needed (or as required by their employers), course by course, if not concept by concept.

All this might seem right for corporate training, but what lessons might higher education draw from such a model? On the surface, training is a very different sector than higher education. Most training skills are relatively narrow and well-defined, while ones taught in higher education are usually broader in scope and tougher to quantify. Business skills also typically turnover more rapidly than those targeted by higher education. Microsoft needs new courses every year for the many software products it creates, buys, or modifies; university classes often stay relatively fixed, in part because the topics they address – intellectual and cultural artifacts, from philosophy to algebra – change slowly, if at all. The sectors also differ in the wealth of the clients they serve, as well as on the nature of the skills they target. Businesses routinely spend much more per worker on training than public education spends per student. Training providers can use this high profit-margin to invest in new training technology, while higher education institutions often find the price-tag for new information technology too high.

However, these differences are diminishing; indeed, previously clear boundaries between the higher education and corporate training markets may be beginning to blur. For one thing, higher education institutions are coming under pressure to change their course offerings more quickly and to make them responsive to the demands of business. The resulting curricula often have a much more applied flavor than the ones they are supplanting. Corporate training is also moving in this direction, although from a very different starting point. In the past, most training schemes were vocational (helping mechanics fine-tune skills on new machines, for example); today, more and more cater to "knowledge workers" in their never-ending quest for life-long learning. "Creative thinking" and "higher-order problem solving" – topics once the exclusive domain of higher education – are slowly crowding out learning of routine procedures in training courses. Even now it is hard to distinguish, say, a computer-aided drafting course at a proprietary school from one offered by a community college or a university.

At the same time, although today it is still easier to create courseware for training classes on programming and using spreadsheets, information technologies are becoming increasingly useful in education classes that focus on more complex (and less well-defined) problem solving skills – as many of the Internet and Web tools we reviewed already attest. Further, as these technologies continue to drop in price, higher education should become an increasingly profitable market. In short, education and training are merging in two senses: just as the content of training and higher education classes are becoming more alike, the feasibility and profitability of technology-based courses for higher education is rising to the level of computer-based training.

Reflection: Higher education, external providers, and information technology: Fight, flight, or friends?

How, then, does information technology affect higher education's problems in competing with new external providers? If anything, it is exacerbating them, not easing them. Several strands of evidence argue that proprietary providers already think that information technology has helped reduce delivery costs to the point where even "down market" (read: higher education) services can be delivered profitably. A growing number of companies, for example, now straddle both sectors, in many cases offering essentially the same courseware products to each. Academic Systems (http://www.academic.com/), to take one, recently had a banner year in both areas. Just after receiving $12 million from Microsoft, TCI and Accel partners to develop corporate training programs that can be dialed-up on a user's home computer, it got high marks in for its CD-ROM-based algebra curricula in Cal State classrooms.

This is just one example of what will probably be a important trend in the coming decade. Several niches are apparently ripe for technology-based educational services – all facets of what eventually may be a vast market in adult learning. For-profit companies are tapping each of them aggressively. Academic Systems is marketing directly to higher education institutions. Others, like The Teaching Company, look primarily to the home market. Many of them also offer educational software to corporate clients as well. In the past, corporate training has focused mainly on job-specific skills: companies are naturally reluctant to pay employees to acquire broadly valuable skills, since these skills will make them more attractive to other firms too, not just more valuable to the employer. However, businesses now also are under increasing pressure to provide remedial learning for employees (learning that probably should have been completed in college or even high-school, but was not). In different guises, all these growing areas are calling for roughly the kinds of learning that higher education typically has offered. But, except in traditional higher education markets (young adults coming straight out of K12), universities and colleges are largely ceding these opportunities to proprietary providers.

Higher education institutions, as a whole, have not formulated any plans to deal with the increasing encroachment of external providers on their turf. They need to. These providers enjoy a couple of advantages over higher education that enable them to devise very creative systems for delivering training and education on the Internet and Web. To begin, many are technically savvy and heavily capitalized. (Today, for example, Microsoft probably invests more on educational technology R&D than the federal government.) This means that external education providers often have both the financial and intellectual assets they need to experiment with high risk/high gain educational designs. Perhaps more important, though, when designing schools or other delivery systems for learning, external providers have the great luxury of starting with a clean slate: no need, for instance, to assume classes will meet at a set time, to worry about faculty displaced by software, nor to fight with teachers' unions. This means that when external providers craft their designs they can focus on what the technology makes possible and what services their clients demand, rather than worrying about how to shoehorn new designs into existing educational structures. At the very least, then, these providers offer some innovative models for using information technology that higher education should attend to. But, after learning from them, what actions to take?

One approach is to shore up defenses against invaders into traditional higher education markets. This can be done, for example, by erecting protectionist barriers which discourage new providers from entering the battle. Some would argue the tax supports which public institutions now enjoy do just that. Perhaps a more positive tactic is to improve productivity in the face of new competition. Many of the enterprises we have reviewed – distance learning campuses and virtual universities, for example – can be regarded as ways higher education already is trying to become more productive, sometimes by borrowing models of delivery from the training sector, and often by creating innovative models of its own.

A different strategy is to take the offensive, rather than honing defenses. In part inspired by movements of external providers into higher education's turf, a few institutions are beginning to respond to the challenges posed by external providers by moving, however cautiously, into contract training. Of all higher education institutions, the community colleges have shown by far the most initiative here (see Figure 30). Five years ago about half community colleges did some contract training with business; today about 90% do. Some community college experts even see training as the solution to their financial problems, and expect contract training will become the biggest piece of the community college system.

Figure 30

Higher education invades corporate training

CORPORATE TRAINING

Although community colleges have been in the corporate training marketplace for some time, they now are reaching out more aggressively, and the American Association of Community Colleges says that about 90% of its member colleges are involved to some extent in the business of training workers for specific companies, rather than just teaching generic subjects or trades. Cost-conscious community colleges have a natural advantage competing for this business against four-year institutions, which may be too proud, too well-off, or too bureaucratic to show much real interest in the training needs of the local business community. A key indicator of successful community college corporate programs is the college's willingness to bring instruction to the client's workplace, rather than requiring students to come to its campus. (David Stamps, "Community Colleges Go Corporate," Training Dec95 p36)

Still, higher education faces several imposing difficulties in this migration. Some are technical. Corporations, for example, expect personalized, on-site training services; and, as we have reviewed, external providers increasingly deliver these tailored courses through wired or even satellite-based network technologies. Community colleges will need comparable tools, in order to offer quality courseware at a competitive per person price that is equally responsive to clients' needs.

Other challenges are organizational, reflecting the fact that community colleges (unlike external providers) do not have a clean slate on which to build their contract training services. Business clients, for example, frequently expect to be able to mix their instructors with college personnel; however, this often conflicts with union contracts between faculty and colleges that forbid hiring external staff. Also, some contracting arrangements threaten informal or formal community college rules that require them to serve mainly local needs (tough to adhere to if contract training is shipped across the state via networks), or that demand classes be open to all students (senseless, if courseware is designed with specific corporate clients in mind).

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While the community colleges struggle to compete with external providers in the contract training market, other higher education institutions are starting to evolve different strategies – some that involve cooperative partnerships as much as competition. In this battle, the size of long-established universities, while often a liability in times that demand nimble change, actually can work to their advantage. For one thing, some training needs are so vast that they attract only the biggest providers. Michigan, for example, recently announced a large-scale educational program that would use the Web to deliver a wide range of courses (see Figure 31). Centered around the Virtual Michigan Auto College ("Auto U"), the idea is to help train the next generation of auto industry workers, and thus to keep the industry firmly centered in Michigan. This is far too big a training job for any proprietary training school to manage by itself, so the plan is to build Auto U as a collection of state schools, lead by the University of Michigan, and all tied together through the Web.

Figure 31.

"Auto U"

MICHIGAN FOCUSES ON THE AUTO JOBS OF THE FUTURE

DETROIT, Feb 28. – The Governor or Michigan today called for a large-scale education program that would use computer networks and tax credits to help train workers for future job openings in the automobile industry.

...

The Governor said that to boost skills the state would create a virtual university called Auto U, consisting of courses taught on the Internet. Students could use computers to take classes focusing on the auto industry.

In addition, [Governor] Engler said the state would at as a sort of employment agency for the auto industry. The Michigan Employment Security Commission will use applications – in person and over the Internet – to screen job seekers.

(Wall St. Journal, Feb 28 1996.)

Although details are far from worked out, Auto U looks innovative from several perspectives. First, courses will presumably be designed by teams drawn from Auto U and business partners, giving business a much stronger voice in curriculum planning than it usually enjoys. Second, the Internet apparently will play multiple roles here, beyond connecting students with instruction and linking businesses into course design. Using Web sites connected to Auto U, the State's employment commission will provide instant access to all Michigan on-line automotive information for students and prospective employees. Students will even be able to take virtual occupation tours, learning directly from workers about the types of jobs available in plants today and the skills needed to do them (see also Figure 26). Auto U looks, in short, to have the key trait of healthy electronic learning communities: beginning with one or two core functions, they quickly grow new ones, as well as adding new stakeholder groups. The third interesting feature of Auto U concerns one of these groups. In addition to public higher education institutions, the Auto U partnership will also include some for-profit trainers. As such, it may be one of the first examples of a cooperative arrangement that includes higher education, external training providers, and business.

Since Auto U is still barely off the drawing board, it is too early to tell how this cooperative partnership between higher education and external providers will work. Any number of options are possible. Perhaps reminiscent of Athena, principal partners (the University of Michigan) might retain considerable control, and contract out specific courses or services to specialized providers; more like MOLI, the higher education partners could manage, set goals, and ensure courseware quality, while delegating much courseware development to external partners; even less constrained relationships, as exemplified by GNA, might work. One common feature in all of these options, though, is role that the Internet and Web will play in tying together the different partners in this evolving community. As we have seen, networks permit courseware and design discussions (as well as instruction delivery) to be shared readily – both within institutions and across their boundaries. This can enable a collection of very different (and physically remote) institutions to jointly construct new educational curricula. Absent rich network connections, in the past, such heterogeneous models of education and training delivery simply were not feasible. But, if Michigan can make this inaugural experiment work, these models may become increasingly popular in the future.

PLANNING AND POLICY: HOW TO MAKE BEST USE OF THE INTERNET AND WWW IN HIGHER EDUCATION

Anyone who began reading this paper expecting simple prescriptions for how to increase productivity in higher education using information technology might be confused at this point, if not disappointed. Far from sketching an easy fix, we have reviewed a wide collection of different Internet and Web-based applications to education and training. And the applications are not just numerous, but differ along many dimensions. Distance learning systems aim (at least primarily) to increase access to learning while reducing costs; cutting-edge applications such as intelligent tutoring systems and simulation-based trainers increase the quality of learning, but will not help institutions deal with shrinking budgets (at least in the short-term); individual publishing may be the best way to provide a new generation of learning materials that are responsive to consumer and business needs (although this approach is much newer and less certain than traditional publication); on-line communities might help meeting many problems in higher education (yet most seem to operate outside current institutional structures rather than within them); and external providers of training and educational services are making some of the most innovative uses of the Internet (but it is rarely clear how higher education should use these models and whether to do so in new markets like contract training or in more traditional venues). The bad news is that the discussion must get a bit murkier still; the good news is that afterwards we will compensate by offering some much more specific recommendations about how higher education should think about the Internet and WWW in its future planning.

Reality Check: What really works now and what will work in the future

Many of the reviewed applications of information technology and the Internet in higher education look enticing. But before beginning what might be an extensive and costly reorganization to accommodate them in classrooms, universities naturally would like some assurance that these new tools can really deliver what they seem to promise. So, how solid is the evidence that the various Internet and Web technologies can really address important goals and problems in higher education?

Not very. Without question, some educational tools have been evaluated very carefully (see Figure 2 for examples). Many distance learning programs in higher education, for example, have demonstrated that the cost of delivering courses can be reduced substantially, while keeping student outcomes roughly constant. A few "augmented" distance learning programs have also improved student learning. For instance, at Stanford students learning physics through Tutored Video Instruction (where students watch videotaped lectures, replaying them off-site using a small group, cooperative learning format) outperformed students who actually attended lectures. Similarly, at both the high-school and college level, some of the best intelligent tutoring systems have fulfilled their goal of increasing the quality of student learning. Algebra, Geometry, and computer programming tutors developed at Carnegie Mellon University, to take one of the most well-known successes, can raise scores on exams up to full letter grade. On a broader scale, meta-analyses – which aggregate results of many separate experimental studies – show a smaller, but still statistically significant effect of computer-based education.

In many ways, the data for corporate training are both simpler and more compelling than for education. Most companies want to train employees on relatively well-defined skills (competence using word processors, spreadsheets, or more specialized tools and software, for instance); improvements in proficiency here can be easily measured. By the same token, it is easy to gauge how much is saved by delivering this training through video rather than using in-person instructors, as are the additional gains in flexibility and further cost reduction achieved by moving from conventional video to Web-based TV delivery systems. For many corporations these results are impressive enough to justify investing billions dollars a year in technology-based training.

But these clear successes of information technology in education and training are limited in many ways. First, as the examples from corporate training suggest, most of the solid evidence concerns a few very well-defined skills. Standard tests can reliably measure how accurately a spreadsheet is used, how fast an algebra problem is solved, and even how well a software routine is written. However, although these are valuable talents, they only scratch the surface of the kinds of abilities we want higher education, if not corporate training, to foster. Those important skills – some specific to particular subjects, and others more "generic", like "collaborative problem solving" – are difficult to measure; and, therefore, it is correspondingly difficult to show that information technologies improve their learning. But, then, for these skills, it is impossible (at least for now) to demonstrate that *any* method of instruction delivery, exploiting the Internet or not, leads to improved learning. If this limitation disproportionately affects tools for learning and teaching that make heavy use of information technology such as the Internet or Web, it is (as previously noted) because they are often strongly associated with curriculum reforms that advocate teaching new, probably valuable, but certainly ill-defined, kinds of knowledge.

A more straightforward reason why there is little data demonstrating the value of Internet-based learning is simply that these applications are very new. While earlier generations of distance learning have acquired a certain pedigree with time, distance learning courses that rely on high bandwidth networks are now at most a few years old. This is barely enough time turn a raw course prototype into a production-quality curriculum, let alone to collect a serious body of data showing how well students learn or how much schools might save.

This leads to a broader point. In general, the information technology applications about which we know most are the ones that have been around the longest. Conversely, the newest Internet and Web applications have little evidence to prove, or disprove, their value for higher education. Unfortunately, these are just the ones that, at least in theory and by logical argument, hold the most promise in confronting key problems in higher education. So, anyone who insists on an air-tight case before adopting a WWW technology will certainly be inclined to disregard, at least for now, some of the most cutting-edge ideas and applications. Digital libraries that amalgamate holdings across institutions, individual publishing ventures, cyberspace lecture halls, electronic communities of practice, and virtual universities: none of these can claim yet to be sure bets for higher education.

The question is how best to deal with this uncertainty. Plainly, an ultra-conservative approach, that accepts only proven technologies in higher education, is likely to be as irresponsible as radical approach that embraces everything which looks appealing. In one case costly errors will be committed; in the other case valuable opportunities may be missed. In deliberating this choice, it may be instructive to reflect on lessons that businesses learned, often painfully, as they integrated information technologies into the workplace over the last 15 years.

To simplify only slightly, businesses generally have taken a very radical approach, early on adopting information technologies with relatively little forethought about which ones best meet their needs, or how they might change work practices. As a result, it has taken many years – and many billions of dollars – to demonstrate significant productivity gains attributable to information technology. But, finally, these gains have materialized, partly through a more careful evaluation of technology options, partly because the structure of the workplace has transformed to make best use of these new tools, and partly because productivity itself has been redefined.

Higher education, now poised to take a similar plunge into information technology, can learn several things from these experiences. The first is that, eventually, the Internet and Web will probably live up to some of the promises offered by the examples we have reviewed. Second, however, it is likely that this success will materialize slowly; that many applications which now appear to be most promising will not pan out; and, conversely, that some which eventually will succeed spectacularly are not even on the horizon today. Third, as we have suggested several times, many successful applications will require modest or substantial organizational change on the part of higher education institutions.

One lesson we must not draw from business experiences, though, is that higher education should be willing to spend billions of dollars just to begin to see returns on investments in information technology. The resources simply do not exist to follow such a radical strategy, even if our educational institutions had the stomach for such wild experimentation (a questionable assumption, to be sure). Nor, we argue, is this necessary. Having let business bear the brunt of being the earliest adopters, higher education can, we believe, take a less radical and less costly approach and still reap the gains. But this will still require a substantial commitment – no ultra-conservative strategy – and careful planning to avoid as many pitfalls as can reasonably be foreseen. The remainder of the paper will consider some of the pieces of such a strategy.

Policy issues discussed and bypassed

Our discussion has surfaced, but not resolved, dozens of important research questions and policy issues. Here we focus on just a few, picking ones that have received relatively little discussion in higher education, while sidestepping a few that recently have benefited from in-depth analysis. For example, several studies outline in detail new methods of learning and teaching afforded by information technology (more authentic and project-based curricula, among others) and the changes in class organization, as well as teacher education, needed to realize these practices. Instead of repeating these discussions in higher education (virtually all educational technology research and policy work is at the K12 level), we will focus on several broader issues:

- Rather than sketch how a particular higher education institution can increase its Internet capacity, we will overview the issues that confront higher education as a whole, in acquiring the hardware and capacity needed to realize Web-based learning on a broad scale.

- Rather than advocate specific ideas for teacher education, we will consider how universities (and education schools) might broadly be reorganized, exploiting Internet technology, to facilitate faculty learning and the encourage the creation of high-quality products for learning.

- And, rather than discuss the costs, benefits, and processes involved in realizing particular technologies (say, a virtual university) we will outline the kinds of questions need to be answered to select from among different technology models.

How will higher education acquire sufficient Internet infrastructure?

On the surface, possibly the biggest barrier to moving higher education onto the Internet and Web in a big way is technical feasibility. Many higher education institutions are now developing and implementing technology plans for distance learning around technologies with much less functionality than the Web will shortly offer – for example, videotape sent through the mail, one-way TV (over cable channels) augmented with two-way audio (through telephones), or two-way video-conferencing using special-purpose hardware. To some of them, a proposal to use the Internet and Web for fully interactive, high-bandwidth, and multimedia courseware must look very premature. Perhaps, some will say, this is the Cadillac (if not a Mercedes) we all might be able to enjoy ten years from now; but, we need to get started today – even it is means beginning with an Escort (if not a Yugo).

Is the idea of using the Internet and Web on a broad scale today in higher education very unrealistic? Is this functionality beyond the admittedly modest, if not shrinking, pocketbooks of universities and colleges? It is true that many higher education institutions have virtually no "Web presence" at this time. California's community colleges, for example, represent over 100 schools and serve more than 1.5M per year; but as of April 1996 over 25% are not connected to the Internet at all.[11] And, of those that are wired, nearly half just provide brief electronic brochures advertising the campus and its mission. This is certainly a long way from the ample Internet capacity education institutions will need to support richly interactive course materials and electronic learning communities.

However, in one sense, this is looking at the glass as half empty. Higher education institutions, in general, are very well represented on the Internet. This is hardly surprising, since for its first 25 years the Internet (until 1990 called the ARPANET) mainly was inhabited by universities, non-profits, and government agencies. True, colleges and smaller universities still lag behind, but the larger schools remain among the most extensive and sophisticated users of Internet and Web resources – even today as commercial sites rapidly take over cyberspace. Web sites like GNA and Athena already show that higher education can manage mid-sized, if not yet large-scale, Internet enterprises. Put most positively, the Internet is probably the only information technology where that higher education has more than kept pace with the business world, both in its raw capacity and its skill in creating useful products (on a given day, the average university classroom surely logs more web-site "hits" than phone calls). In one sense, then, to realize many uses of the Web we have reviewed, higher education needs to preserve its position on the Internet more than to gain new ground.

Commercialization of the Internet and Web, though, sometimes is viewed as jeopardizing that position, and as a threat to the small pristine academic community that used to be cyberspace. Much of this concern is well-founded; today, most of the early free-wheeling and unregulated "electronic frontier" already is long gone. One of the specific complaints against the commercial expansion of the Internet, however, is that it will steal capacity, soon filling the pipes with cybercasts of "Instant Baseball"[12], for instance, and potentially crowding out quality educational material. Maybe so, in the short run; but in the longer term, commercialization actually may benefit higher education in several ways.

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[11] See Web site http://www.cerritos.edu/cccco/ccc-list.htm for a list of California Community College Internet resources.

To begin with, capacity short-falls triggered by huge increases in demand for Internet services are being met quickly, as providers rapidly lay down new fiber-optic cable, and devise clever ways of using old physical infrastructure (copper telephone wire, cable TV, as well as broadcast spectrum) to meet new needs. All of this is being driven by the commercial sector, of course; but education can benefit too. Not only will this capacity expansion mean that educational material need not be crowded out, it actually suggests education should have even more room to work with than in the past, and better tools to make use of that capability.

One of the reasons skeptics view the Internet as an inadequate infrastructure for distance learning is that, even in its pre-commercial glory days, it just did not supply the bandwidth needed to deliver rich instructional material, such as two-way video, in real-time. Today, for example, viewing short (and non-interactive) video-clips using a 28.8 modem and your favorite Web browser is a painfully slow experience – enough to make educators take refuge, again, in instructional TV. Commercialization of the Web will change this. Within the next year or two a collection of new software and hardware products – from cable modems that provide hundreds of times the capacity of old phone lines, to fractal compression algorithms that shrink movies so they fit comfortably on old phone lines – will, in effect, permit the Internet to carry interactive multimedia courseware, including video, from education servers to most homes (ones that have cable TV or home computers, at least) and to virtually all businesses.

At the same time as commercial interests have expanded the capacity of the Internet, new tools, along with economies of scale, are causing prices to drop dramatically. For example, videoconferencing (in business as well as educational settings) used to require special-purpose and costly hardware. Now it can be done equally well on the Internet, using ordinary PCs equipped with cameras (some machines come with these already built-in) and running software tools like CU-seeMe. Although costs and features will vary somewhat from site to site, Internet videoconferencing on average probably costs about one-tenth of special-purpose systems (CU-seeMe itself is free). And this savings does not factor in the greater flexibility of Internet videoconferencing: special-purpose videoconferencing systems only deliver instruction in one way; networked PCs can be configured for videoconferencing, or for many of the other instructional models we have reviewed here.

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[12] Instant Baseball is an Internet site that uses a Java-animated ballfield to present, in virtual-real-time, nearly every play in a Major League baseball game. Instant Ballpark provides animation, lineups, the status of all current games, and personalized replay of any part of any game played during the current season. See http://www.instantsports.com/baseball.html

Issues and policies for acquiring Internet infrastructure

In short, then, commercialization of the Web, far from threatening higher education's position, is providing the tools and capacity needed to create and deliver interactive, multimedia, courseware at very low prices. But this is still a long way from saying how specific institutions should go about building their Web products, how they can be guaranteed the broadest and least expensive Internet access, or how much wiring universities and colleges might cost. Several recent studies have offered cost-estimates for wiring primary and secondary schools on the Information Superhighway, describing the characteristics and prices of various connectivity models. We are not aware of comparable analyses at the post-secondary level, and it is beyond the scope of this paper to offer one.[13] However, we will discuss a few broad issues and specific strategies that can help higher education keep Internet costs to a minimum, while increasing access and functionality.

Coordinated technology plans and purchases. The simplest thing higher education institutions – actually *all* educational institutions – should do is to change their model for technology acquisition. Today, schools at all levels buy hardware, infrastructure, software and support services for computers and networking in a piece-meal fashion. This usually reflects funding mechanisms that provide only small yearly technology allocations, and also rely heavily on intermittent donations from large foundations or corporations. Sometimes these windfalls enable institutions to build impressive technology-intensive centers through substantial one-time investments. But, to put together broad technology infrastructures, in the long run higher education would do much better if technology purchases were planned more systematically, as corporations do, and especially if acquisitions were coordinated, across a whole campus, institution, or even a system of schools.

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[13] The cost of providing Internet and Web capability, say, to all public higher education institutions across the country is yet another topic worthy of an in-depth analysis. Several models, differing primarily in richness of connectivity and end-user hardware, would need to be considered. To estimate costs accurately, the current levels of Internet penetration would have to be taken into account, as would the price of generating courseware and educating faculty.

Currently, telecommunication providers generally regard education as a collection of small, sporadic buyers of computing goods and services, rather than as large consumers whose purchases are driven by a well-designed technology plans. As always, big organized buyers will get much more for their dollar than small inconsistent ones. This is a pity because education is actually a huge industry, but one that is handicapped because of its fragmentation. By coordinating purchases around a coherent vision, higher education institutions would obtain much better prices; perhaps more important, they could command the kinds of personalized services that only major industries like aerospace and entertainment now enjoy.

Exploiting a window of opportunity provided by the Telecommunications Act of 1996. As important as it is for higher education to develop long-term technology plans and form large-scale purchasing alliances in order to negotiate effectively for Internet infrastructure, less direct policy actions may be even more crucial. State and federal debates are now setting the stage for regulations that will influence the quantity, quality, distribution, and cost of telecommunication infrastructure and services over the coming decades. New laws forged during these deliberations will certainly change the character of the Internet in many ways, potentially affecting educational applications just as profoundly as other commercial ones.

The centerpiece of this legislation of the Telecommunications Act of 1996. The Act touches on a wide range of issues dear to the hearts of communications giants, electronic publishers, and the entertainment media. Baby Bells are now free to provide long-distance services, once barriers that block competition in their local markets are removed. Long distance carriers may enter those local markets. Rules that govern cable TV have been relaxed, although cable companies will feel competition from telephone companies who are permitted now to carry video programming. Also relaxed are media concentration rules that, for example, once prohibited TV networks from owning cable systems. In contrast, laws that govern content generally have been tightened by the Act. Television manufacturers are required to equip all new TVs with the V-Chip, that would allow parents to block indecent programming. And new regulations on the Internet go several steps further than the V-Chip, making it a crime to transmit material considered indecent to minors.

With the Act's passage, many think the best window of opportunity to influence policy in ways that will benefit education is now gone. Not so. In fact, the Act ignores several critical issues, delegates some decisions, and defers yet others to later dates. A brief sampling of some of these still-open opportunities (see Figure 32) shows that

Internet capabilities available to higher education, and their costs, could look very different, depending on the outcome of political fights still to come in Washington and the states. In the best-of-all-worlds, consumers would pay modest amounts to access courseware across the Web regardless of distance, providers would have multiple paths through which to distribute their courseware, and both would have relative freedom to use copyrighted material for learning purposes. In the worst-of-all-worlds, consumers would pay substantial sums to access courseware at a distance, providers would enjoy few options for distributing materials, and the content produced and consumed would be severely limited by extremely tight intellectual property laws.

Figure 32

What the Telecommunications Act of 1996 Doesn't Tell You

Issue	*Implications for Education*
Universal Service. The Act only provides broad guidelines for universal service. The real fights will take place at the state level, between the FCC and Public Utilities Commissions.	Local battles will decide what universal service means now, and how it evolves over time. Eventually it could include Internet and broadband access for all. Now it just covers phone service.
Consumer Protection. Federal and state regulatory agencies still must set up rules governing competition in local phone (and often cable) markets. Long distance companies are already fighting for a "modem tax".	These local battles will have direct effects on consumers choices and rates. They may also impact Internet costs; currently they are low, and independent of distance. Long distance phone companies are challenging this.
Intellectual Property. Decisions concerning intellectual property rights were not addressed in the Act. Congress is currently holding separate hearings on this.	At stake is whether current principles of fair use and public domain will apply to electronic communications. The current administration White Paper would make even browsing copyrighted documents an infringement.
Spectrum Auctions. Spectrum decisions were initially part of the Act, but stricken at the last minute. At issue is whether networks will be granted spectrum for free, or whether it will be auctioned by the FCC (garnering tens of billions of dollars).	If spectrum is auctioned, proceeds could be reinvested, for example, to wire schools and fund educational services. Alternatively, if spectrum is not auctioned, TV networks could be required to dedicate fixed amounts of bandwidth to education and training.

Whether the world turns out closer to the best-of-all, or more like the worst-of-all, will depend, in part, on how effectively advocates argue higher education's case over the next year or two. Based on past history, prospects look bleak indeed. While publishers, cable, and telephone companies have powerful lobbies in Washington, education's cause in the telecommunication reform debates is being championed only by few educational organizations and a handful in Congress.

Higher education is about as fragmented when it comes to political advocacy as it is in technology acquisition, and with similar results – or lack of results. If higher education could patch together its uncoordinated constituencies, however, it could achieve the size, and eventually the clout, of powerful lobbying organization like the American Association of Retired Persons. Even a group with a fraction of that weight might help turn many on-going telecommunications debates in favor of education. But this would require different institutions to unite behind a broad common vision of what they want to do in education, and what technology tools are required to get the job done – to become, if necessary, a single-issue group that sends a consistent message about the telecommunication infrastructure it will need in the next century.

How will individual learners access Internet-based education?

Even if higher education institutions can secure the infrastructure needed to supply generous amounts of richly interactive courseware across the Internet, only half of the problem is solved. The rest will be accomplished when consumers – students of all ages – are able to interact comfortably and cheaply with these products. Many already can, of course. But, if education on the Internet is to be as readily available as education in the classroom, then students of all ages will need virtually universal access to on-line courseware. Today, this is not the case.

Assuming that cable TV, upgraded phonelines, or new wireless paths can bring the Internet to the door (admittedly a somewhat open question), students still need machines on which to display, process, and even create digital courseware. Right now, the only machine that does this is a personal (or bigger) computer, that, adequately equipped for Netsurfing, costs about $2000. Roughly a third of U.S. households have at least one PC; however, while this number is steadily growing, it is not changing very rapidly, in part because PCs remain persistently several times more expensive than other information appliances, such as TVs. This means that the next decade, at least, will see a gap of 50% or more between our goal of universal access and the percentage of homes that are likely to have PCs.[14] Can this gap be completely closed, and at what cost?

Technology changes, ushered in by commercialization of the Internet, certainly will shrink it somewhat. PC prices will continue to drop and this, combined with increases in computer demand (in part to access Internet and Web products), will draw some consumers on-board. But, the advent of dedicated Internet appliances (at perhaps $500 per unit), or possibly Web televisions (which for about $1000 allow passive TV watching as well as more active Web browsing), are likely to have a more immediate impact on Internet access. How much and how quickly this shrinks the universal access gap is anyone's guess. One generous conjecture might be that, within a decade 75% of households would have some kind of Internet machine – roughly mid-way between the number that have Cable TV (65%) and that have VCRs (85%).

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[14] The percentage of households that have *access* to a PC, of course, will be higher than the percentage that own one; some might use computers at the office, or perhaps at public sites such as libraries. Using computer access numbers rather than computer ownership ones, therefore, will reduce the gaps we calculate somewhat. But not enough to change our argument significantly. Moreover, one might argue that a level of Internet access adequate for education would necessitate PC availability "anytime, anywhere" – generally best achieved at home.

If we are serious about a commitment to universal access, policy instruments rather than technological ones, probably will be needed to cut further into the remaining 25% gap. The policies that are appropriate will depend on who comprises this remainder. Many ideas have been considered: universities could supply machines for students (some already do); older computers might be recycled to low-income students; libraries and other community venues could provide Internet access; manufacturers might consider pay-terminals (analogous to pay telephones); and governments could use vouchers as well as other forms of cross-subsidy. It is beyond the scope of this paper to articulate policies in detail, or to outline who they should target (but, see RAND's "Universal Access to Email" study for very relevant analyses). Suffice it to say that students most in need of help will not only be relatively low in income, but also in education. In short, many of those who would profit most by Internet appliances will be able to afford them least.

How will higher education acquire quality courseware and educate faculty?

If universities and students soon enjoy lavish Internet capacity, they still will need quality Web products for learning that make good use of this potential. To judge by current offerings, this will take a long time. As any Netsurfer knows, most Web sites offer little of value; and the useful educational products that do exist are tough to find, usually hidden in isolated pages rather than combined into well-organized structures, akin to textbook chapters or libraries. On top of that, the first generation of tools for creating Web documents are far from "user-friendly". Faculty who build homepages need to be skilled word processors, understand the rudiments of HTML (hypertext markup language, the current de facto standard for Web products), have access to tools that translate files among several different text and video formats, and even program in Java, if they want to develop educational products that are highly interactive.

In spite of these challenges, there are several reasons for optimism. First, as we have seen, Web-based courseware is already beginning to flourish, and sites such as the

World Lecture Hall, GNA, and MOLI are adding several layers of organization to these individual products. In doing so, they are both facilitating access by students, and making it easier for faculty to find and build new on-line courses. Second, and related, courseware is becoming easier to construct, in part because much Web publishing is based on a non-traditional model for creating content: instead of starting from scratch, new courses are often built from previous ones, using simple digital cut-and-paste. This is just one example of how the Web encourages rapid development by facilitating layering of products on one another. Here, layering means that individual faculty will be able to build much courseware using just simple editing tools; not all will need to master programming skills usually required to create courseware from the ground-up.

Third, it is even becoming easier to create courseware from scratch, when necessary. Driven by a rapidly evolving commercial market, software vendors are now coming up with a new generation of tools that will automate much of the construction Web courseware. Two years ago constructing even the simplest Web homepage required at least a bit of HTML coding. Today faculty can use off-the-shelf tools to create many multimedia products with virtually no direct programming. Some tools convert existing documents into Web-ready format (e.g., "rtftohtml" takes Word documents as input and generates HTML ones as output); others build new homepages through dialogues with users (e.g., Microsoft's "FrontPage"); yet others provide high-level graphical interfaces, delegating the synthesis of low-level HTML code to underlying software (e.g., "HoTMetaL PRO"). And, predictably, a few Web publishing wizards have put together sites that organize many of these diverse authoring resources, providing a valuable starting point for those interested in learning about them (e.g., Microsoft Office Web site, http://www.microsoft.com/FrontPage/productinfo/featuredetails/tools.htm).

Finally, and perhaps most importantly, on-line information sources and support communities abound that will help even the most novice faculty member develop the necessary Web and Internet skills. These take several forms, ranging from simple "FAQs" (lists of Frequently Asked Questions, plus answers), to detailed hypertext documents on the art of HTML programming, to newsgroups and listservs that engage in more active discussions on how to provide Web services. All this is free. For a fee any of hundreds of start-up companies that now offer Web product-development support gladly will assist institutions or individual faculty in designing and implementing Internet sites of any size – or do it for them. [15]

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[15] We do not discuss these providers in detail, in part because we assume higher education, unlike many other businesses, cannot afford to outsource such services. However, partnerships might be feasible.

Issues and policies for acquiring quality courseware and educating faculty

Even if all these tools and supports help faculty become comfortable creating and teaching Web-based distance learning courses, higher education institutions will probably need to consider several kinds of changes and policies to smooth what might be a very substantial transformation for many teachers. An obvious first step might be to offer courses that give faculty hands-on training with Web publishing technologies, and, more broadly, that demonstrate examples of good Web-courseware and principles for creating useful educational products on the Internet. But who will provide such teacher training services?

Who will teach the teachers? It is natural to expect that education schools would continue to play a substantial role here. Certainly they will need to revamp many programs to help faculty acquire new teaching skills – ones better suited to technology-intensive classrooms, that, in the future, will be less dominated by lecture and more driven by collaborative projects or on-line mentoring. But to delegate all training on Web publishing, as well as on new teaching practices, to education schools might risk duplicating services unnecessarily, since, as we just noted, on-line communities are already poised to do much of the job. Here is yet another case of new electronic communities that criss-cross the boundaries of traditional higher education institutions. Higher education must find strategies for coordinating with them – in this case if only because much of the literature and training they offer is good, and free.

Courses and communities might help faculty acquire skills in Web-based courseware development, but one big question remains: where will the time and money come from to pay for all this? We suggest that it can be done at roughly current levels of funding – providing faculty can reallocate the time they devote to different teaching activities. As we have noted, information technology is slowly beginning to displace faculty in some of their traditional teaching roles; students will spend more time working with smart software or watching digital lectures, and less time listening to live discourses. This might tempt some schools to cut staff and thus reduce costs. Alternatively, faculty could be retained and use their newly freed-up time to fulfill other roles. One role that may expand is intensive coaching, to help students learn in difficult cases where even rich interactive software is not enough. Or, faculty could spend more time creating courseware.

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if (as with Internet infrastructure) universities would coordinate their fragmented constituents, in effect becoming a large consumer that could command first-rate Web development services for cut-rate prices.

Thus, one answer to the question of how to acquire better quality on-line courseware, and to educate faculty to create and use it effectively, is simply to recommend that faculty be given more time and resources to engage in these activities. If the transition from lecture-intensive curricula to Web-based courseware is managed reasonably, this added course development time may come at little or no increased cost to higher education institutions. In effect, the outlay should come out of savings in direct teaching costs. (In the longer-term, of course, it may also be more productive to hire new faculty whose strongest teaching skills are in courseware development rather than lecture delivery. But that is a different policy decision.)

Nourishing grass-roots publication. Higher education institutions can also encourage the development of higher quality Web courseware through tactics that help foster and manage the "grass-roots" or individual publishing which we see taking shape in on-line communities like the World Lecture Hall. Universities and colleges could follow GNA's lead and provide a common infrastructure for on-line courses. The fact that many contributions in these databases already come from higher education institutions suggests that even today universities have much courseware to organize. Perhaps they would do even better to copy proprietary institutions like MOLI that supply value-added services which establish goals and areas for new courseware, offer technical assistance to courseware developers, and furnish quality-control standards.

Setting standards for courseware format will probably be as important as content standards, at least in the long run. If faculty develop materials in diverse formats that do not "interoperate" the chances of creating new courseware using simple cut-and-paste tools diminish greatly. Lecture overheads rendered, for example, in PowerPoint do not mix easily with Adobe Photoshop representations. On the other hand, if universities encourage faculty to build on-line courses that adhere to emerging Web document standards, in effect they will invite sharing of course products. One of the great strengths of the early Internet, veterans will say, is that intellectual products – software and ideas alike – were shared freely. The past was never really quite so grand, but it is true that the tradition of "freeware", "shareware", and "open systems" has been strong on the Internet, and it will probably continue to be essential, in some form, if individual publishing in higher education is to prosper.

Several things threaten this culture of sharing, and higher education should keep them in mind, if not actively work to keep them in check. One, discussed previously, concerns copyright and, more generally, intellectual property rights. Legislation now being drafted in Washington may cripple almost any sharing of materials copyrighted to publishing firms. However, individual faculty publishers (or their institutions) also should have protection for their intellectual products. Many professors (and some universities) already make substantial sums selling courseware (usually as books, but increasingly in educational software). Like big publishers, they too may be reluctant to share their materials without any compensation. As always, the challenge is to strike a balance that rewards innovation enough to keep new ideas (here courseware) flowing, while also maximizing their social benefits (here the sharing and use of courseware).

Individual faculty, their institutions, and higher education as a sector, have yet to work out clear policies that define a workable balance point. These decisions are tough enough when restricted to a single college or university, but take on added complexity when courseware is shared across institutions or even states, not just within them. Virtual universities like The World Lecture Hall and MOLI will catalogue courseware from any publisher that meets their standards (non-existent in the case of World Lecture Hall) regardless of location. In doing so, they recognize that one of the most powerful features of the Internet is that encourages the free flow of ideas and course materials to any place in the country (and around the world). This is an idea that most states and public universities have yet to come to terms with.

While higher education institutions might be happy to provide infrastructure, training, and other value-added services to help faculty produce higher quality courseware, their idea of sharing, it seems, stops at the academy door, or at least at the state boundary. One of the biggest issues higher education institutions will have to face, in the near future, is simply that state and academy barriers are much tougher to defend against invading software than national barriers are to defend against, say, illegal aliens. Laws will need to be rewritten to reflect the fact that courseware which might be in college on-line catalogues will probably be derived from, or even wholesale copies of, products found in other university databases. Nor should this be viewed as simply bowing to the inexorable forces of network technologies that make editing and transmitting digital materials trivially easy. If managed properly – for example, through careful quality controls and well-organized cataloging services – the net effect of promoting, rather than discouraging, this sharing can be a dramatic gain in the quality of Web-based courseware.

One cost of this freedom, of course, will be that the boundaries between different institutions may begin to blur, at least when it comes to course offerings, if not research reputations (however, in some disciplines, inter-institution research collaboration is also increasing) and social functions. Such blurring suggests that, in the future, some universities might be more brokers of education, reminiscent of MOLI and GNA, rather than "full-service" providers. Should all universities have course development as central to their educational mission? Answering this question, however, goes well beyond understanding how higher education institutions can help foster high-quality courseware on the Web; it touches on the deeper issues of new models of educational delivery that information technologies enable. In the last section, we will briefly touch on this complex topic.

How will higher education make choices about new delivery models for education?

The previous sections addressed broad issues of feasibility and capacity: how higher education could to acquire the Internet infrastructure it will need; and, similarly, how quality courseware and adequate teacher education might be assured. But this says nothing about how such capabilities will be put to work. Assuming higher education has the financial, physical, and human resources necessary to use the Web and Internet, what structures or models should it adopt to deliver educational services?

First some sweeping statements, then qualifications. The dominant model of delivery in higher education is still "one-stop shopping": a single provider offers all educational services (including counseling, course creation, course delivery, student evaluation and accreditation, whole course collections leading to degrees, and often even job placement support), at a single location (consumers are expected to come to the provider, not the converse). One theme that runs through our argument is that new information technologies add substantially to the set of models that providers can consider; many of the case-studies we have reviewed demonstrate that some of these different delivery structures already have moved from the drawing-board into practice. Broadly, these models unbundle educational services, and repackage them in different ways. Today some highly specialized providers offer only a few courses, rather than large sequenced collections; some broker courses rather than create them; and others create and deliver courses, but in partnership with several providers rather than solo.

Now some qualifications. First, models other than "one-stop" shopping certainly existed prior to the information revolution. Mass education, including primary and secondary schools, vocational and training institutions, as well as colleges and universities, may be the most common formal method of learning; but, many of us remember (albeit often not fondly) taking piano or dance lessons from highly specialized providers. And, although marginal in this country, intensive apprenticeships have persisted as powerful learning methods for centuries – so much so that many hope information technologies soon will make "cognitive apprenticeships" feasible on a large scale (see Figure 10). Second, new information technologies are not the only reason different models of education delivery are beginning to flourish. Growing markets for adult learning services require changes in traditional delivery models; consumers of on-the-job training, for example, insist on courses that are highly tailored specific needs, rapidly changeable, and delivered at the workplace, not in the schoolroom.

But new information technologies are supplying most of the raw materials from which delivery models that meet these demands can be fashioned. In the past, regardless of demand, it was prohibitively expensive to consider, say, creating courses for a widely scattered and relatively small group of consumers; now distance matters little in the economics of such services. And, once only the largest corporate training clients could expect "housecalls" from education providers; today size counts for much less, because on-site education can be done mainly through high bandwidth network "virtual visits". Time is also less of a factor: "housecalls" from education providers never came "on demand"; now educational courseware can be accessed across the Web 24 hours a day.

The idea that information technologies can (and should) radically transform processes and products in education may seem odd or even objectionable to many. Maybe stranger still, though, is why this should sound controversial when such talk seems routine in discussions of manufacturing and service industries. The idea that the Internet might help reduce costs of courses or improve the quality of students' learning still draws doubts from thoughtful pundits like Larry Cuban and Neil Postman; but no one questions that the same tools help produce lower-priced and higher-quality cars. The view that technologies could help speed the creation of courses or help build courses tailored to specific learners seems original and off-beat; yet "just in time" manufacturing is familiar to anyone with even a passing knowledge of business. And, while the idea that a monolithic education institution might be unbundled into a collection of services looks altogether foreign, it is the industry monolith who sometimes looks out-of-touch with modern views that businesses often do much better by specializing, and perhaps partnering with others to develop products.

Questions in a space of alternative education delivery models

One way to encourage discussion of different models of educational delivery enabled by new information technologies such as the Internet and Web might be to try to systematically attempt to characterize the vast "space" of alternatives. But this probably would be as futile as trying to describe all the ways that businesses could restructure using new technologies. Instead, we will limit ourselves to posing a series of questions – most stemming from the different applications of the Web and Internet we have reviewed

– that summarize a wide range of ways the structure of educational services could change (and are already transforming) to make effective uses of new information technologies. We deliberately pose the questions as challenges to facets of the familiar "one-stop shopping" model, not necessarily because it is flawed, but more because points in the "space" of alternatives nearby familiar models are likely to be explored, while more distant ones may go unnoticed. The list is by no means complete, nor is each question addressed with great care. More than anything else, we hope to trigger discussion of these unusual, and sometimes useful, alternatives.

- *Knowledge "chunks": Why are courses so long?* Courses in higher education usually extend across many weeks. Quarters and semesters vary in size somewhat across institutions, but not radically. And, within institutions, there is no in size variation at all. Courses offered to corporations by external providers, on the other hand, are often no more than a few hours in length, and are driven by the needs of the client and requirements of the material, rather than the conventions of the providers. "One size fits all" courses certainly make bookkeeping easier for degree-granting institutions, and probably are impossible to circumvent if classes must meet at scheduled times and places. But, if students learn mainly at a distance, can choose to start a course when they wish, and access courseware "anyplace, anytime", perhaps courses of variable length, tailored to the needs of the subject (and, of course, to the needs and learning style of the student, as well), are feasible.

- *Course flexibility: Why offer only a few courses per subject? Why not add to course listings in an on-going fashion?* Most universities and colleges change their course offerings only slowly, at least as compared with MOLI and GNA. On the surface, increasing speed of course creation and the diversity of courseware could only help consumers, assuming value-added counseling services were available to help them select the product that best match their current level of expertise, educational goals, and learning styles. Tools that permit faculty to create new Web products rapidly certainly will help expand the range of courseware a university offers. However, MOLI and GNA enjoy even more flexibility because they invite outside developers, not just their faculty (in fact they have none), to develop on-line materials. Whether or not institutions can offer a large pool of courses, therefore, will probably depend on changes to other structural features, some noted below.

- *Why limit class enrollment?* Most university courses place caps on the number of students they will admit, and on the size of individual classes. In prestige institutions, this often means that demand outstrips supply in ways that more market-driven service industries never see. Recent experiments CUNY, and long-term successes at the Open University, argue that distance learning technologies can open up enrollment, while keeping costs under control and quality reasonably high. As demand for quality adult education continues to grow, various models of "partially open" enrollment might be worth considering. A school might, for example, allow anyone to take a distance-learning course on the Web for a nominal fee, subject to the constraint that they access only on-line resources (lecture materials and electronic quizzes seen in courses on the World Lecture Hall, for instance). Students could also pay additionally for more labor-intensive services, such as on-line tutoring, and proctored exams.

- *Why should faculty spend more time (in teaching, not research) directly delivering information rather than engaged in other functions, especially courseware development?* If open or partially open enrollments become more common, the direct involvement of faculty in delivering education (e.g., through live lecture) probably will diminish, since more and more students will access recorded and interactive materials on-line, rather than attend classes. At the same time, other teaching functions, in particular the creation of courseware that is accessed at a distance, will become increasingly important. Models that emphasize content development over delivery will probably also change hiring practices; new faculty may need to be as skilled at multimedia publication as they are at playing "sage on the stage"

- *Why should universities develop courseware? Why not concentrate more on value-added management and brokering services?* Perhaps some universities could do away with courseware development, as well as direct course delivery. Examples like the World Lecture Hall and the Global Network Academy suggest models of educational services where functions traditionally bundled together as "one-stop" shopping are now separated. Institutions that specialize in organizing courseware developed by others could offer several advantages to consumers. They could warehouse many courses on a single subject, giving consumers a wide range of choices. Alternatively, like the Teaching Company (see Figure 11) they might concentrate on offering only the best courseware, from "superstar" faculty. Or, they could concentrate on other important value-added services. For example, the Western Virtual University (http://wga-internet.westgov.org/smart/vu/vu.html) is not planning to develop or deliver courseware, but will conduct needs assessments to determine areas where course offerings are insufficient, provide quality assurance and assessment tools to measure student learning (and course efficacy), establish requirements for degrees and other credentials, as well as supply centralized services including libraries and student records. More broadly, in such models, higher education institutions would supply high-level management, resources, and vision; many of the specific tasks would be done by specialized providers.

- *Why not pool common information resources, like libraries?* While in some new models universities might unbundle services and specialize in a few key functions, alternative models might package together pieces that are typically separate. For example, as we have noted, pooling courseware across institutions would give consumers greater freedom of choice. By the same token, it makes good sense to aggregate electronic libraries across institutions: students lose nothing if a virtual library is "moved" off-campus, and will gain access to richer collections, if their library is merged with other holdings. These are just two examples of educational models that try to exploit some potential benefits of the free-flow of information across institution, state, or even national boundaries.

- *Why not partner with for-profits as well as other non-profit and public providers?* If higher education institutions explore delivery models that unbundle services, they will also need to consider various alternatives for partnering with other providers – institutions that provide the services they have decided to delegate, and with whom they will need to coordinate, if they still wish to offer "full service" education. In particular, given that the for-profit sector (mainly high-tech corporate training) is expanding much more rapidly than traditional higher education, various "heterogeneous" models that include a mix of public and private institutions will need to be considered. Today, this country spends about as much on for-profit educational services as in public education; shortly corporate training alone will exceed higher education in size. Thus, if higher education remains separate from these other players in the adult learning market, in relative terms, their presence will continue to diminish.